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OF

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VOL. XXXIX.

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B

I.—INTRODUCTION.

THE Review of Mineral Production published as Part I, Vol. XXXII of these *Records* surveyed the progress made in the years 1898 to 1903. In that Review it was explained that, although many valuable mineral products were being worked in different parts of the country, it was impossible to obtain statistics about some of them sufficiently precise to be of any value as figures. The most conspicuous of these 'minerals' are the various forms of building material and slate, which are naturally used extensively in every district, and would form an excellent index of material progress if we could rely on the figures returned, and could regard those of one period to be fairly comparable with those of another.

Grouping of the minerals.

In order to obtain some mental impression of progress, we are compelled to exclude from the list of minerals contributing to the statement of total values, those about which we can obtain only partial figures or rough local estimates. The minerals are thus reviewed in two groups as before, namely—

Group I—Those for which approximately trustworthy annual returns are obtainable; and

Group II—Those regarding which regularly recurring and full particulars cannot be procured.

The minerals now considered in Group I are:—

Chromite.	Magnesite.
Coal.	Manganese-ore.
Diamonds.	Mica.
Gold.	Petroleum.
Graphite.	Ruby, Sapphire and Spinel.
Iron-ore.	Salt.
Jadeite.	Saltpetre.

Tin.

Units recognised.

Unless otherwise stated, the *ton* referred to in this Review is the English statute ton of 2,240 lbs. Where there are totals likely to be of interest to foreign readers, weights are also expressed in metric tons of 1,000 kilogrammes each (equal to 0·984 statute ton). Returns in *maunds* have been translated into tons, cwts. and qrs. throughout. The output of petroleum has been given in Imperial gallons, and totals are expressed also in *metric tons* assumed to be equivalent to 249 gallons of crude oil of an average specific gravity of 0·885. Values are given in sterling calculated throughout at the rate of Rs. 15=£1, which has been the fixed rate of exchange throughout the period of this and the previous Reviews.

Sources of information.

The data employed in this Review have been obtained from various sources. Previous to 1904 the Annual Statistics of Mineral Production were published by the Director-General of Statistics, now the Director-General of Commercial Intelligence. During the period now under review, the figures of mineral production for India have been published annually in the Records of the Geological Survey of India. During the first three years the annual figures of mineral production were supplied by the Local Governments to the Director-General of Commercial Intelligence, who passed them on to the Geological Survey; but as this did not allow of a thorough and prompt check on the figures, a change was introduced beginning with 1907 and now all returns of mineral production are sent by Local Governments and Political Agents direct to the Geological Survey Office, except in the case of mines under the Mines Act, when the figures are forwarded direct by the managers of the mines to the Chief Inspector of Mines who forwards a summary to the Geological Survey. Information regarding exports and imports has been taken from the publications issued by the Director-General of Commercial Intelligence. Additional information has been obtained from the following sources:—

(1) Annual Returns of the Chief Inspector of Mines in India and the Chief Inspector of Mines for Mysore.

(2) Annual Returns of the Gold Mining Companies of the Kolar, Dharwar, and Hutti Fields, kindly supplied by the Managing Agents.

(3) Annual Administration Reports of the various Local Governments and Local Administrations in India.
(4) Annual Administration Reports of the Railway Board.
(5) Returns issued by the various Geological Surveys, and Statistics relating to Mines and Quarries, published by the English Home Office.

We are also indebted to the Managing Agents of several Mining Companies for much information supplied direct.

II.—SUMMARY OF PROGRESS.

Total values.

The following table summarises the values of the principal minerals produced during the six years under review. The totals have the obvious defect of being due to the addition of unlike denominations: for export values, being the only returns obtainable in some cases, are ranged with spot values, while the latter necessarily vary with the position of the mine, representing not the *values*, but the *prices* obtainable. In the case of coal, for instance, the so-called value of a ton of good coal in Bengal is less than half that of the inferior material raised in Baluchistan or Burma; in the case of salt, the values given are the prices charged, and these, on an average, are but one-seventh of the duty, which is the principal value of the salt to Government; certain valuable mineral products, such as building-stone, are omitted altogether for want of even approximate estimates.

The values returned for minerals exported are also necessarily lower than they would be if the minerals were consumed in the country, and it is consequently unfair to compare this table of values with corresponding returns for countries in which metallurgical industries flourish. Manganese-ore is a conspicuous example of a product which, according to its quality, may be worth 30 to 40 shillings a ton to the European steel-maker, but which is of less value to the Indian producer by the heavy cost of transport. The country is thus not only so much poorer by the loss of the metal exported in the ore, but is paid in return little more than half its market value.

Comparison with the previous period.

The imperfections of the table are those confessedly inseparable from all such estimates of mineral production; and it is of use merely as a means of comparing one year with another, the same system being carried through the whole period

TABLE 1.—*Total Value of Minerals for which Returns of Production are available for the years 1904 to 1908.*

Minerals.	1903.	*Average for the period 1898-1903*	1904		1906	1907	1908	*Average for the period 1904-1908.*
	£	£	£		£	£	£	£
Gold . .	2,302,493	*1,904,719*	2,367,290	2,428,164	2,231,479	2,126,756	2,177,847	*2,266,307*
Coal (*a*) .	1,299,716	*1,225,677*	1,398,826	1,419,443	1,912,042	2,609,726	3,356,209	*2,139,249*
Manganese-ore (*c*)	188,509	*154,845*	142,443	262,696	874,499	1,361,996	517,166	*631,760*
Petroleum (*a*)	354,365	*185,810*	473,971	604,2		610,015	702,009	*592,887*
Salt (*e*)	336,147	*347,897*	437 530	441,392	420,901	434,076	522,794	*451,359*
Saltpetre (*b*)	288,487	*262 603*	266,349	235 723	270,547	274,679	292,758	*268,012*
Mica (*b*)	86,277	*80,120*	83 183	142,008	259,543	226 382	139,513	*170 126*
Ruby, Sapphire and Spinel.	98,575	*89,345*	90,612	88 340	96,867	98,258	47,954	*84,406*
Jadestone (*b*)	47,676	*44,770*	59,418	51,615	59,137	62,195	74,402	*61,353*
Graphite (*a*)	16 970	*11,981*	17,029	15 566	10 022	7 411	14,365	*12 879*
Iron-ore (*f*)	14,963	*13,581*	11,055	15 257	14 728	12 657	15 149	*13,769*
Tin-ore (*a*)	9,153	*6,875*	8,348	9 016	13 799	11,882	11,015	*10,992*
Chromite (*a*)	327	*51*	4,137	3 482	7,188	24 404	6,338	*9,110*
Diamonds .	2,579	*766*	2,636	2,474	5,160	2,784	940	*2,799*
Magnesite (*d*)	550	*519*	351	550	488	50	2,009	*689*
Amber	414	*362*	858	945	709	385	364	*648*
TOTAL .	5,047,201	*4 329,927*	5,364,016	5,721,774	6,751 347	7,863,656	7,880,832	*6,716,325*

(*a*) Spot prices (*b*) Export values (*c*) Export values of quantities actually exported.
(*d*) Estimated value (*e*) Prices without duty (*f*) Estimated values for provinces other than Bengal.

under review. In the period of the previous Review there was a steady uninterrupted progress in production from a total of £3,455,565 in 1898 to £5,047,201 in 1903, an increase of 46·06 per cent. in five years. During the period now under review this uninterrupted progress has continued from a total of £5,364,016 in 1904 to £7,880,832 in 1908, an increase of 56·14 per cent. in the five years from the end of the previous period to the end of this period. Comparing the totals for 1908 of the present period with those of the last year (1903) of the period previously reviewed, increases are noticed, in some cases very large, in the values of all the minerals given, with four exceptions:—(1) *gold*, for which there has been a slight decline in value from the maximum reached in

1905, although the average annual value for the period has been greater by £360,000 than in the previous period; (2) *rubies*, for which there was a heavy drop in value in 1908 owing to a decrease both of production and prices, although the average annual value during the period has been only £5,000 less than in the previous period; (3) *graphite*, although the average value for the period is about £1,000 greater; and (4) *amber*, the average value being £286 greater. Diamonds and chromite were not included in this table in the previous Review.

Comparing the average values of the minerals produced during the period 1904 to 1908 with those of the previous period, an increase in value is noticed in every case except rubies, the decrease in this case being small.

General character of the minerals worked.

On looking over the returns for mineral production in India for the past five years and comparing them with the previous period of six years, the two features noticed in the previous Review are seen to stand out just as conspicuously as before. Firstly, practically the whole of the remarkable increase is due to the progress in developing six minerals, four of which—coal, petroleum, gold, and salt—are consumed by what conveniently may be called direct processes, and two of which—manganese-ore and mica—are raised for simple export. Secondly, there has been, with few exceptions, a continuance of the remarkable neglect of the metalliferous ores and the minerals that are necessary to the more complicated chemical and metallurgical industries.

The neglect of metalliferous ores.

The principal reason for the neglect of metalliferous minerals is the fact that in modern metallurgical and chemical developments the bye-product has come to be a serious and indispensable item in the sources of profit, and the failure to utilize the bye-products necessarily involves neglect of the minerals that will not pay to work for the metal alone. Copper-sulphide ores are conspicuous examples of the kind: many of the most profitable copper mines in the world could not be worked but for the demand for sulphur in sulphuric acid manufacture, and for sulphuric acid there would be no demand but for a string of other chemical industries in which it is used (*cf.* page 278). A country like India must be content, therefore, to pay the tax of imports until industries arise demanding a sufficient number of chemical products to complete

an economic cycle, for chemical and metallurgical industries are essentially gregarious in their habits.

During the period under review a certain amount of serious attention has been given to the development of bauxite, copper-ore, and lead-silver ores, and it is probable that during the succeeding quinquennial period, 1909 to 1913, the smelting of some of these ores in the Indian Empire will become firmly established. The most promising province in this respect is Burma, where the smelting of lead slags from Bawdwin commenced in 1909 (see page 254).

Comparison with foreign mineral production.

Although such great progress has been made during the period under review in the development of the mineral resources of India, the relative insignificance of the total value will be seen by comparing the 1907 figures for India in table 1 with those for the twelve most important mineral products of the United Kingdom, the United States of America, and the German Empire given in table 2. From this it will be seen that the value of the coal produced in the United Kingdom was fifteen times the value of the total Indian mineral production; the value of each of ten out of the twelve leading minerals of the United States exceeded the total Indian production; whilst the value of the German coal production was ten times that of the Indian total, and that of potassium and magnesium salts only one million sterling less (as noted on page 12). A factor of great importance to the mineral development of the country is the output of building materials, such as clay, slate, and building stones. This is clearly illustrated in the case of the United Kingdom, where stone, clay, and shale, and slate, rank respectively 3rd, 4th, and 5th in order of value; and in the United States where clay products rank 4th, 'stone' ranks 7th, and cement 8th, in order of value, the value of the clay products alone, by which is meant clay, bricks, tiles, pipes, etc., being more than four times the value of the total Indian production. In the case of Germany no figures for these substances are available and consequently none appear in the table. It will further be noticed what an important part in the mineral production of each of the three countries cited is played by the ores of the metals used by the arts, such as those of iron, lead and zinc in all three countries, of copper in two of the countries, and of gold, silver, and tin, each in one country.

TABLE 2.—*Values during 1907 of the Twelve Leading Mineral Products in the United Kingdom, United States, and Germany.*

United Kingdom. (*a*)		United States of America. (*b*)		German Empire. (*a*)	
	£		£		£
Coal . . .	120,527,378	Coal .	126,242,073	Coal (including brown coal) . . .	77,530,900
Iron-ore .	4,433,418	Pig-iron	108,820,945	Potassium and magnesium salts, excluding alum .	6,657,700
Stone (*c*) . .	3,870,860	Copper .	35,687,741	Iron-ore .	5,080,900
Clay and shale .	1,850.387	Clay products	32,637,037	Zinc-ore . .	2,114,650
Slate .	1 178,600	Petroleum . .	24,662,577	Copper-ore	1,335,100
Oil-shale . .	806 323	Gold . . .	18,569,959	Salt (sodium chloride)	1,123 500
Tin-ore (dressed) .	706,700	Stone (*c*)	14,600,781	Lead-ore . .	1 006,600
Salt . . .	648,596	Cement	11,479,230	Petroleum	352,800
Lead-ore	419,247	Natural gas	10,855,613	Alum and aluminium sulphate . .	210,100
Chalk . . .	200,882	Lead . .	7,948,172	Sodium sulphate	114,950
Gravel and sand	183,625	Silver .	7,659,076	Iron pyrites . .	86,100
Zinc-ore . . .	100,533	Zinc	5 421,337	Manganese-ore .	56,300

(*a*) Value at mine or quarry.
(*b*) Value at place of production ; in most cases, of products obtained from the raw materials.
(*c*) Limestone, sandstone, and igneous rocks.

Imports of minerals and mineral products.

In this place, also, it will be interesting to note the values recorded for imported minerals and for products obtained directly from minerals during the period under review. These figures, exclusive of the values of cutlery and hardware, machinery and millwork, railway plant and rolling stock, earthenware and porcelain, glass and glassware, jewellery and plate of gold and silver, paints and colours, and alizarin and aniline dyes, are shown in table 2A. From this table it will be seen that the imports of minerals and products directly obtained from minerals have increased from £11,425,962 in 1904 to £14,478,744 in 1908, the average annual value being £12,037,022. If the figures in the last column, showing the average values for the period 1904-08, be compared with the average figures for the three years 1901-03, given on pages 185 and 186 of Volume XXXII of these Records, it will be seen that there has been an increase, during

the five years under review, of nearly £2,000,000 over the average of the three years referred to, and that this increase has been distributed over all the items, with the exception of quicksilver, mineral oil and paraffin, and precious stones and pearls unset, in which there has been a decrease in the average annual value of £3,805 £457,781, and £240,241, respectively. The chief increases in the average annual imports have been in copper, iron, and steel, the amounts of increase being £394,854 for copper, £702,950 for iron, and £999,771 for steel.

TABLE 2 A.—*Value of Imports of Minerals and Products obtained directly from Minerals for the years 1904 to 1908 (including Government stores).*

——	1904.	1905.	1906.	1907.	1908.	*Average.*
	£	£	£	£	£	£
Salt . . .	471,095	417,997	488,127	525,065	502,427	*480,942*
Metals . Brass .	69,946	71,806	61,390	84,429	112,796	*80,073*
Copper .	1,751,744	1,173,110	1,194,489	1,106,190	2,202,950	*1,485,697*
German silver.	127,563	113,771	109,916	164,210	140,595	*131,211*
Iron . .	2,808,915	2,287,365	2,845,403	3,434,645	3,352,963	*2,945,858*
Steel .	1,799,173	2,099,696	2,401,504	3,113,361	3,174,907	*2,517,740*
Lead .	129,315	151,118	118,769	154,667	148,060	*140,386*
Quicksilver	27,472	23,284	27,258	20,218	24,087	*24,464*
Tin . .	263,194	188,913	187,337	259,403	296,839	*239,137*
Zinc . .	110,891	93,446	131,000	111,535	101,889	*109,932*
Unenumerated.	81,244	140,776	178,354	151,662	110,262	*132,460*
Total of Metals .	**7,169,457**	**6,343,285**	**7,256,320**	**8,600,320**	**9,665,408**	*7,806,958*
Inorganic Chemicals.	395,018	465,280	438,755	514,282	494,793	*461,626*
Mineral Oil and Paraffin.	2,230,795	1,767,441	1,483,138	1,946,417	2,572,681	*2,000,094*
Coal, coke and patent fuel.	325,613	252,495	295,456	387,450	491,293	*350.462*
Precious Stones and Pearls, unset .	589,679	853,100	696,600	501,411	334,599	*595,078*
Stone and Marble .	17,877	27,714	26,910	28,495	31,876	*26,574*
Other Building Materials.	226,428	295,599	328,880	339,866	385,667	*315,288*
Total .	**11,425,962**	**10,422,911**	**11,014,184**	**12,843,306**	**14,478,744**	*12,037,022*

There is a satisfactory deduction to be drawn from both the decreases and increases: the decrease in the imports of mineral oils indicates the development of our own oil-fields, whilst the increase in the imports of metals indicates the approach of the necessary conditions of market required for the profitable exploitation of the deposits of ore known to occur in this country.

But, in addition to the imports of minerals and of products obtained directly from minerals, shown in table 2A, there is a large import of products of a more finished nature manufactured either entirely, or almost entirely, from minerals or mineral products. These exceed in total value the items given in table 2A; and, in order to indicate the nature of these imports of more finished products, we give below the figures for 1908 of the most important of these imports:—

	£
Railway plant and rolling stock	8,496,408
Machinery and millwork	4,780,485
Cutlery and hardware	2,279,854
Glass and glassware	825,568
Alizarine and aniline dyes	572,446
Paints and colors	331,016
Earthenware and porcelain	289,688
Total	£17,575,465

Comparison of imports with production.

Considering only the year 1908, it will be seen from these figures that the total value of the imports of minerals and products obtained directly from minerals, and of the articles manufactured from these, was over £32,000,000, whilst the value of the mineral production of the country was not quite £8,000,000. It is evident, therefore, that there is a demand in India for products manufactured ultimately from minerals to the annual value of over four times the annual value of mineral production, apart from the fact that a considerable proportion of the mineral imports of India is exported. This indicates better than any other figures the scope there is for the development of the mineral industries of India for the supply of the internal consumption of the country, quite apart from any markets that might be supplied abroad. That India, in many cases, possesses the mineral resources requisite for the supply of this demand can be gauged from the substance of this review.

Summary for the Minerals of Group I.

Chromite.

The production of chromite—which has been transferred to Group I with the commencement of mining operations in Baluchistan in 1903, when there was an initial output of 284 tons—has averaged 6,745 tons valued at £9,110 during the quinquennium, the highest returns being in 1907, when there was a production of 18,303 tons valued at £24,404 owing to a sudden large production in Mysore, where chromite is worked in the Mysore and Hassan districts, particularly in the former. There was a great decrease in production in both Baluchistan and Mysore in 1908 owing to a drop in prices and to accumulations of stocks. Prospecting operations for chromite are being carried out in Singhbhum district, Bengal.

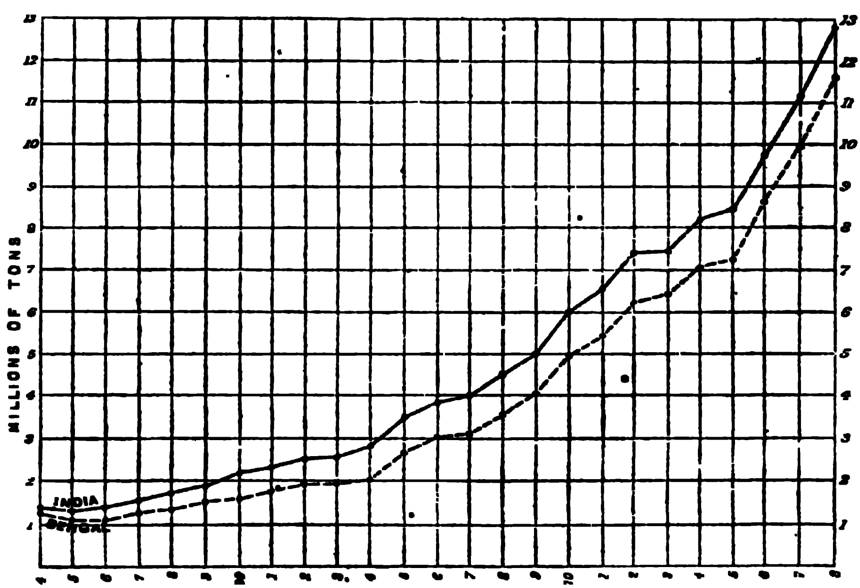


FIG 1.—*Production of Coal from 1884 to 1908.*

Coal.

In the case of coal, the continuous increase in the Indian output recorded for the previous period from a little over four million tons in 1897 to 7½ million tons in 1903, has been followed by an increase during the period under review from a little over 8 million tons in 1904 to 12¾ million tons in 1908 (see fig. 1, page 15). The increase during the past five years has been nearly 72 per cent. and during the past ten years 177 per cent. On page 8 of the previous Review it is recorded that 'India, for the first, though probably also for the only, time, secured the leading place as a coal-producer amongst British dependencies.' This has not proved to be the case. India passed the Australian output in 1902 and since then has gradually increased its lead over the next two countries, Australia and Canada, the output from which is about equal, until in 1907 the Indian output was about a million and a half tons ahead of each of these two countries. By far the larger proportion of this phenomenal increase in the Indian coal production has been obtained from the Jherria coalfield, the output of which has grown from 750,000 tons in 1898 to 6½ million tons in 1908. So that by 1908 the output of the Jherria field had become 50·6 per cent. of the total Indian production and the output of Bengal had increased from 78·6 per cent. in 1898, and 85·5 per cent. in 1903, to 90·5 per cent. in 1908.

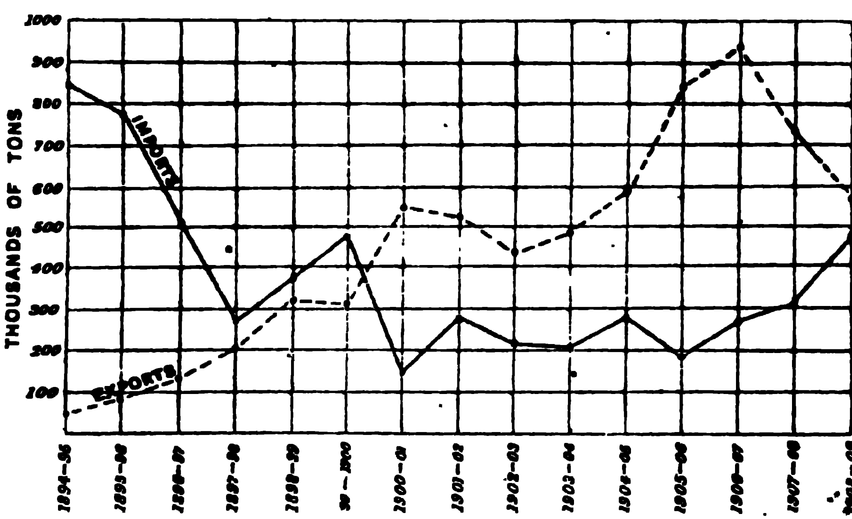


FIG. 2.—*Exports and Imports of Coal for the last 15 years.*

The final stages of this remarkable increase in the Indian production were marked by what might be called a 'boom' during the years 1907 and 1908, when demand kept ahead of supply, so that the average prices obtained during 1908 were higher than any previously recorded and in consequence of which many new coal companies were put on the market, several of which were doomed to failure from the beginning.

The greater part of this increase must be ascribed to the normal development of trade, for there has been no development of the metallurgical industry within the range of coalfields and the general nature of the coal-consuming industries has not changed. Thus the quantity of Indian coal consumed on the railways has increased from $1\frac{1}{2}$ million tons in 1898 to $3\frac{1}{2}$ million tons in 1908, whilst the Indian coal consumed on railways has formed 29 per cent. of the total production during the period now under review, this being exactly the same figure as held for the previous period 1898—1903, and indicating that railway expansion has kept pace with the coal-consuming industrial enterprises.

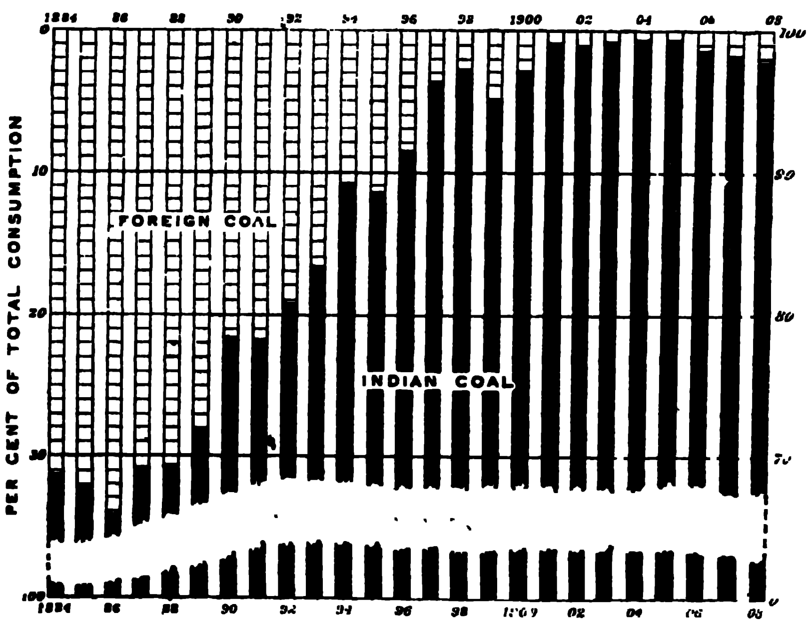


FIG. 3. *The relative consumption of Foreign and Indian Coals on Indian Railways during the 25 years 1884 to 1908.*

The imports of foreign coal have varied from 200,000 tons to 300,000 tons and the exports between 500,000 tons and 900,000 tons, thus maintaining the relative positions of the figures for imports and exports first established in 1900 (see fig. 2, page 16). Owing to the great demand for coal during 1906 to 1908 and the enhanced prices, the proportion of foreign coal used on the railways, although still insignificant, rose to 2·1 per cent. of the total consumed on the railways (see fig. 3, page 17).

Diamonds.

Diamonds have also been transferred to Group I during this period. The production has fluctuated, the average for the period being 306·7 carats valued at £2,799. This production refers to the Central Indian States of Panna, Charkhari, and Ajaigarh. Some attention has also been given by prospectors to the diamond-bearing deposits in Anantapur, Banganapalle, and other portions of the Madras Presidency.

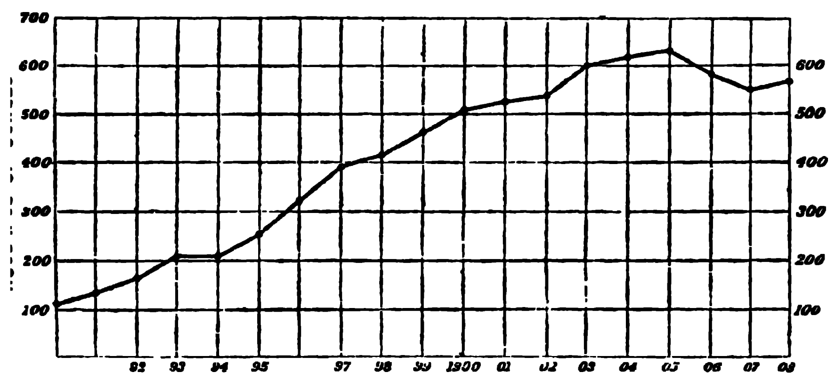


FIG. 4.—*Production of Gold since 1890.*

Gold.

During the period previously reviewed a steady increase in the production of gold was recorded, from 390,595 oz. valued at £1,568,065 in 1897 to 603,218 oz. valued at £2,302,493 in 1903. This increase continued to a maximum of 631,116 oz. valued at £2,428,162 in 1905, since when there has been a small decline, the production for 1908 being 567,780 oz. valued at £2,177,847. This decrease is due to poorer ore having been reached in the lower levels of some of the mines in the Kolar field, from which by far the largest fraction of the Indian gold output is derived. These mines

seem to be improving again and the slight increase in the 1908 output over that of 1907 has been continued into 1909. The changes in the Indian gold production since 1890 are shown in fig. 4, page 18.

The reef-mining commenced at the Hutti mine in the Nizam's Dominions during the previous period has led to a continuous production of gold with payment of dividends during the period under review. There has also been a small production of gold on the Dharwar field since 1905, but the work there has, so far, given somewhat disappointing results. Promising development work has been carried out on the Anantapur field discovered in 1902. There has also been a continuous production by the Burma Gold Dredging Company operating on the upper reaches of the Irrawaddy river and one of its tributaries, and the first dividend was paid in 1908.

Graphite.

The average value of graphite raised during the period under review has been £12,879 as compared with £11,981 for the previous period. The average annual production has been 2,711 tons, this being a little over 3 per cent. of the world's production.

Iron.

The works at Barakar still remain as the one successful attempt to manufacture iron along European lines in India; the annual average output of pig iron has been 41,919 tons, a slight increase over the previous period. Near Kalimati in the Singhbhum district, Bengal, works are now in course of erection for the manufacture of both pig iron and steel by the Tata Iron and Steel Company, from iron-ore derived from large deposits proved to exist in the Mourbhanj State. The native charcoal iron industry continues to flourish in some of the more remote parts of the Peninsula, but particularly in the Central Provinces, where there has been during the period an annual consumption of 2,189 tons of ore employing an average of 435 small direct-process furnaces, with the production of 557 tons of iron per annum.

During the five years under review, the average value of the unfinished and finished iron and steel imports has increased from £12,883,879 in 1904 to £22,084,677 in 1908, the average value for the period being £16,910,432. The value of the pig iron, iron bars, and steel bars, sheets and beams, has increased from £4,608,070 in 1904 to £6,527,930 in 1908, with an average value

for the period of £5,465,172, the differences between these totals and those given earlier in this paragraph being due to the imports of products manufactured from iron and steel, namely, railway plant and rolling stock, machinery and mill-work, cutlery and hardware. The figures for iron and steel imports show that there is room in the country for a large iron manufacturing industry, which would soon bring in its train the manufacture of machinery, railway plant, etc.

Jadeite.

We are still compelled to rely upon the export returns of 'jadestone' to the Straits and China for a correct idea of the magnitude of the jadeite industry of Burma. The average annual quantity of jadeite exported during the period under review has averaged 3,470 cwt. as compared with the somewhat larger quantity, 3,911 cwt., during the previous period; but the declared value has been much higher, namely, an average of £61,353 per annum against £44,770 in the previous period. As in the period previously reviewed, jadeite stands ninth in order of value in the Indian mineral production, its value being five times that of the iron-ore and graphite and six times that of the tin-ore and not very much less than that of the rubies.

Magnesite.

During the early parts of the period under review the operations conducted on the magnesite of the 'Chalk Hills' near Salem were mainly of a prospecting nature, but a plant has now been erected to calcine the mineral on the spot and future exploitation promises to be on a larger scale. This is seen in the greatly increased production of 1908, namely, 7,534 tons valued at £2,009, the average value of the output for the whole period being £689.

Manganese-ore.

As in the period previously reviewed the phenomenal increase in the mining of manganese-ore in India is the most conspicuous feature in the mineral industry of India. Production began in 1892 with the output of 674 tons of manganese-ore. By 1903, the last year of the period previously reviewed, the output had risen to 177,821 tons. During the present period, after a slight decrease in 1904 owing to the low prices prevailing, the production has increased enormously to a maximum of 902,291 tons in 1907, decreasing with the fall of prices to 674,315 tons in 1908, the average for the whole period being 509,143 tons. In 1907 the

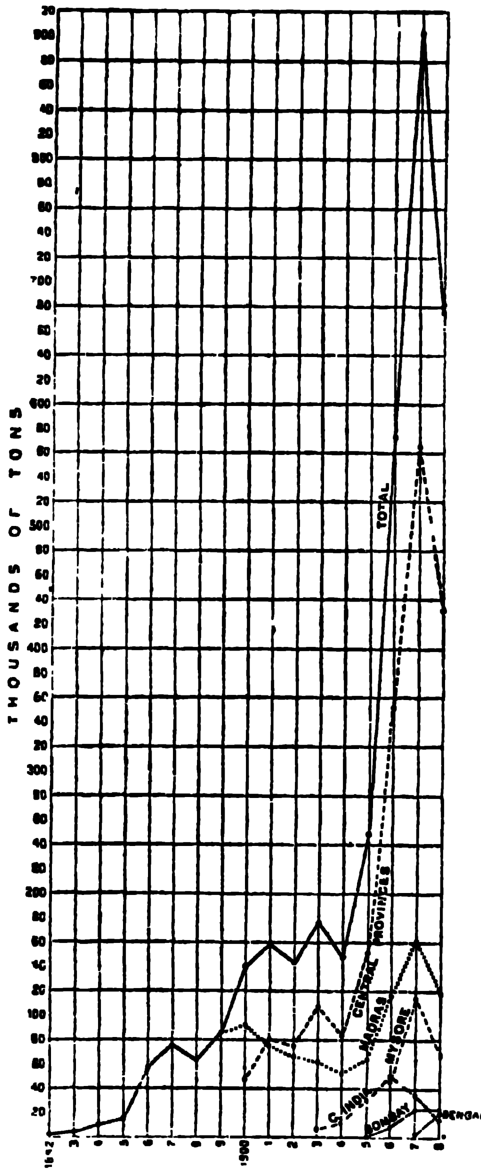


FIG. 5.—*Production of Manganese-ore since the commencement in 1893.*

Indian output was but slightly smaller than that of Russia, and, finally, in 1908, India, owing to a much larger decrease of the Russian output, assumed the first place amongst the world's producers of manganese-ore (see fig. 13, page 133). At the end of 1908 there was a considerable surplus of ore—estimated at some 300,000 tons —lying at the mines, owing to over-production during 1907 under the stimulus of the high prices then prevalent.

The average annual value of the ore produced during the years 1898—1903 was £154,845.[1] This has increased to £767,319 for the period 1904—1908, the maximum value being £1,867,977 in 1907. Taking the average values for the period, manganese now stands third amongst the minerals produced in India, being exceeded only by gold and coal.

Figure 5 shows that, whilst during the previous period manganese-ore was produced only in Madras and the Central Provinces, with an

1 This is much greater than the average value recorded in the previous Review which was £79,44 . The true export values of the total production have now been given and the revised totals may be seen by referring to page 536 of *Memoirs, G. S. I.*, Vol. XXXVII (1909).

initial output from Central India in 1903, during the present period the provinces of Bengal, Bombay, and Mysore entered the list of producers.

The continued export of manganese-ore in the raw condition with the absence of any attempt to manufacture ferro-manganese in India cannot, in view of the unlimited fuel supplies lying idle in India and the annually increasing bill for imported steel, be regarded with unmixed satisfaction.

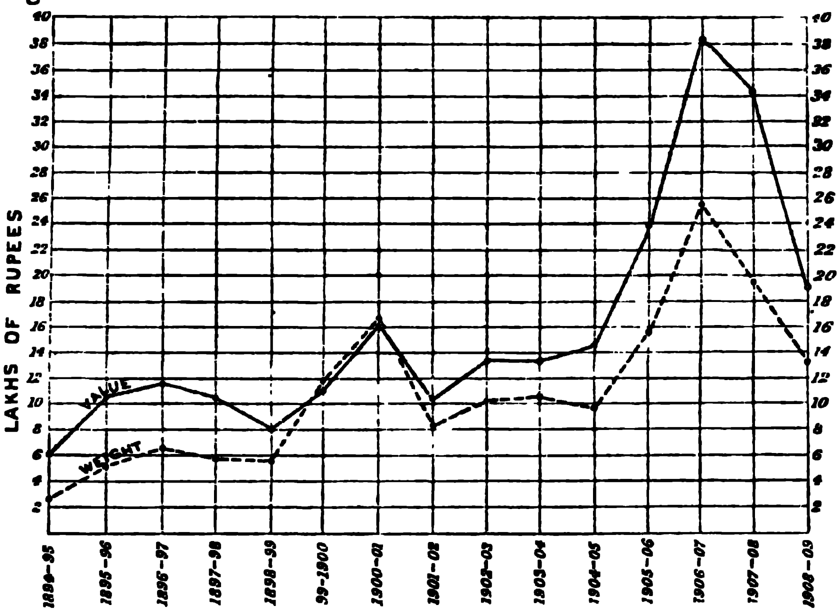


FIG. 6.—*Exports of Indian mica during the past 15 years.*

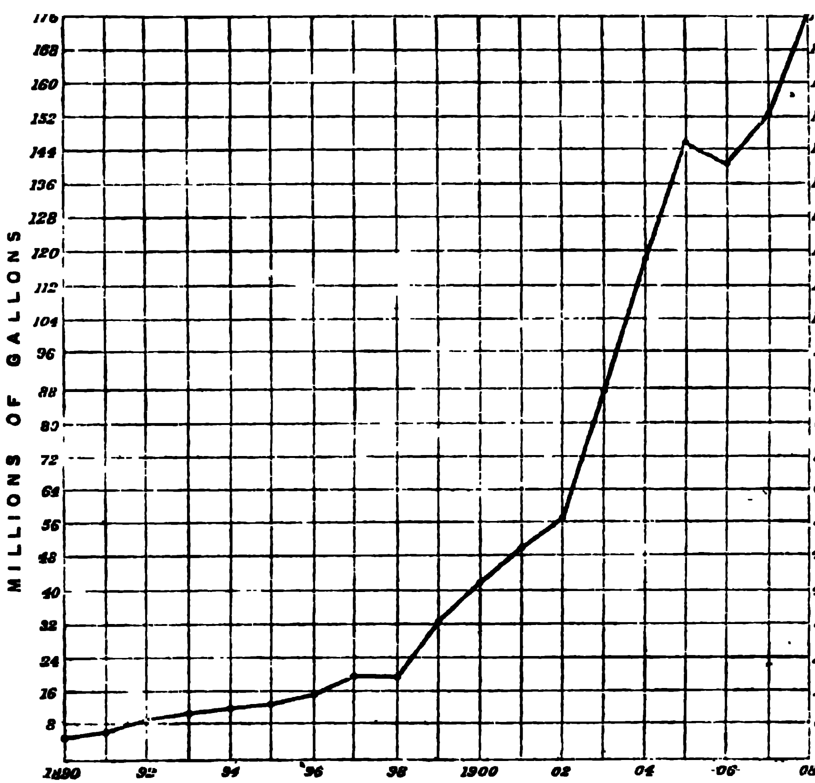
Mica.

The three principal contributors to the world's supply of mica are India, Canada, and the United States of America. During the quinquennial period, 1894—1898, the total value of the mica produced in these three countries was £464,154, of which 68·1 per cent. was due to India; the total value of the mica produced by these three countries during the next quinquennial period, 1899—1903, was £709,785, and the Indian contribution had fallen to 60·1 per cent.; during the present quinquennial period, 1904—1908, the total value of the mica produced amounted to £1,404,203 and the Indian contribution increased slightly, namely, to 61·8 per cent. of the total.

The average annual value of the mica produced in India during these three quinquennial periods has been :—

	£
1894—1898	63,203
1899—1903	85,370
1904—1908	173,511

The great increase in the present period is due to the invention of micanite, which is manufactured from scrap mica ; the cheapness of this product has led to the greatly extended use of mica for electrical purposes.



Production of Petroleum since 1890

FIG. 7.

Fig. 6 shows the fluctuations in the total weight and the total value of the mica exported during the past fifteen years. In the

present period Rajputana has risen to a position of importance as a producer of mica, and has yielded 11·3 per cent. of the total Indian production by weight.

Petroleum.

During the period previously reviewed the production of petroleum increased from 19 million gallons in 1897 to nearly 88 million gallons in 1903; during the present period the production has continued to increase, though at a somewhat smaller rate (see fig. 7, page 23), the figures being from 118½ million gallons in 1904 to 176½ million gallons in 1908. The average annual value of petroleum produced has increased from £185,810 for the period of the previous review to £592,887 for the present period. During the refining of petroleum, paraffin wax, petrol, and other products are obtained, and there has been a great increase during the period in the export of paraffin wax, from 42,940 cwt. in 1904 to 83,572 cwt. in 1908.

Rubies, Sapphire, and Spinel.

Next to petroleum, rubies now form the chief source of revenue amongst the mineral products in Burma, the Burma Ruby Mines, Limited, paying an annual rent of two lakhs of rupees (£13,333) plus 30 per cent. of the annual net profits. The Company has paid dividends continuously since 1898, except on two occasions, the last being the year ending with the 28th February 1909, owing to a slump in the ruby market consequent largely on the world-wide commercial depression. The value of the output of rubies, sapphire and spinel, for 1908, was but half its usual value, and consequently the average annual value of rubies, etc., for the period under review was only £84,406 as compared with £89,345 during the period previously reviewed. In addition to the Burmese rubies this total includes a small production of sapphire from the mines in Zanskar in Kashmir, but work in this area has been again discontinued.

Salt.

The annual amount of salt produced during the period 1904-1908 has been fairly constant, averaging 1,167,785 tons exclusive of Aden, as compared with 979,572 tons during the period 1898—1903. This increase is doubtless partly due to the reductions in the salt tax from Rs. 2-8-0 a maund to Rs. 2-0-0 a maund on the 18th March 1903 and from Rs. 2-0-0 a maund to Re. 1-8-0 a maund on the 22nd March 1905. Of the salt produced 64·5 per cent. was obtained from sea-water, 25·2 per cent. from sub-soil brine and

from lakes in areas of internal drainage, whilst the remaining 10·3 per cent. was raised from the rock-salt deposits in the Punjab and North-West Frontier Province. The average annual import of foreign salt amounted to 484,940 tons as compared with 433,754 tons during the previous period, of which 88·8 per cent. was imported into Bengal and 11·0 per cent. entered Burma.

Saltpetre.

The production of saltpetre is evidently understated, being considerably below the quantities returned as exports. The average annual exports for the five years amounted to 358,989 cwt. as compared with 382,353 cwt. during the period previously reviewed. As, however, the value per cwt. was slightly greater, the average annual value during the period of the present review was £265,135 as compared with £262,603 during the previous period. Of this amount 32·8 per cent. by weight went to the United States, 25·0 per cent. to the United Kingdom, and 22·1 per cent. to Hongkong, the United States rising from the position of third most important consumer during the period of previous review to the chief position during the present period. 56·1 per cent. of the saltpetre was manufactured in Behar and 28·6 per cent. in the United Provinces; 98·6 per cent. of the total left India through the port of Calcutta. The trans-frontier imports of saltpetre from Nepal averaged only 4,156 cwt. annually as compared with 9,417 cwt. in the previous period.

Tin.

The prosecution of tin mining in South Burma by the primitive methods of the Chinese and Siamese has continued during the period; there has also been a considerable amount of prospecting carried out by European syndicates, one of which is engaged in erecting concentrating and electrical power plant near Maliwun in Mergui and promises to become a producer in the near future, working both lode and alluvial deposits. Tin has also been won in the Karenni State. The average annual production of tin-ore in Burma has increased from 1,645 cwt. valued at £6,876 in the period previously reviewed to 1,670 cwt. valued at £10,992 in the present quinquennial period. The industry is expected to attain greater magnitude in the future owing to the interest that has been aroused in these deposits, which are a natural continuation of those in the Malay Peninsula, from which more than half the world's supply is derived.

III. DETAILED ACCOUNT OF THE MINERALS OF GROUP I.

Chromite.

Chromite is known to occur with serpentine and other rocks of the peridotite family in the "Chalk Hills" near Salem, in the Andamans, in Baluchistan, in Mysore, and in Singhbhum. Attempts were made many years ago to work the deposits near Salem, but were not persisted in. No attempt has been made to work this mineral in the Andamans.

Baluchistan.

Work was commenced on the Baluchistan deposits in 1903, the output for the first year of work being returned as 284 tons. The production from the two producing districts—Quetta-Pishin and Zhob—is shown in table 3, from which it will

Table 3.—*Production of Chromite during the years 1904 to 1908.*

Province.	1904.		1905.		1906.		1907.		1908.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Baluchistan	3,596	*4,137*	2,708	*3,482*	4,375	*7,188*	7,274	*9,699*	4,135	*5,513*
Mysore .							11,029	*14,705*(a)	610	*825*(a)
TOTAL .	**3,596**	*4,137*	**2,708**	*3,482*	**4,375**	*7,188*	**18,303**	*24,404*	**4,745**	*6,338*

(*a*) Estimated.

be seen that the total production for the period under review is 22,088 tons, corresponding to an average annual output of 4,418

tons. The chromite is exported from Karachi, and is of high grade, occurring as veins and irregularly segregated masses in serpentines that accompany great basic intrusions of upper Cretaceous age.[1]

Mysore.

In Mysore State chromite has been found in the districts of Mysore, Hassan, and Shimoga. It has been worked in the first two districts only, the production for 1907, the first year of work, being 11,029 tons. As only 201 tons of this total was exported from Mormugao—the port of shipment for most of the minerals of Mysore—large stocks have accumulated, and the production in 1908 fell to 610 tons.

The amount of ore railed to Mormugao by the end of 1908 was 5,947 tons, all derived from the Kadakola area in Mysore district, and nearly all of it from Mr. J. Burr's concession. The amount shipped up to the end of the same year was 3,905 tons.

Shimoga district.

Chromite seems to have been first found in Mysore by Mr. H. K. Slater, who found a rock showing grains of chromite in a talcose matrix near Harenhalli in the Shimoga district.[2] Even the richest specimens did not indicate more than 35 to 40 per cent. of Cr_2O_3.

Mysore district.

The most important of the Mysore chromite deposits is situated near the village of Kadakola in the Mysore district (first taken up on license in 1906). The 'country' consists of gneiss with occasional patches of hornblende-schist. It is cut by a couple of ultra-basic dykes of the dunite series, one of which has been completely altered to serpentine for a length of about two miles. The chromite occurs for the most part as a narrow vein, averaging, probably, not more than 9 to 12 inches in thickness. But in one place it forms a large lens. Several thousand tons of chromite have already been quarried in this area. The ore is of fairly good quality, often yielding on analysis from 50 to 52 per cent. of Cr_2O_3; but a considerable proportion of it is probably of lower grade.[3]

1 E. Vredenburg. *General Report, Geol. Surv. Ind.* for 1902-03, p. 9.

2 *Rec. Mysore Geol. Dept.*, II, p. 129.

3 Report, Chief Inspector of Mines, Mysore, for 1906-07, p. 36.

Hassan district. Chromite has been found in the Hassan district in 1906 over a length of about 20 miles, in some altered ultra-basic rocks—tremolite and enstatite largely altered to talc and serpentine—located in a belt of hornblendic schists. The ore consists, for the most part, of small grains of chromite embedded in a talcose matrix. Some of the better portions of the rock probably contain 30 to 40 per cent. of Cr_2O_3. The Mysore Chromium Company, Ltd., which was formed for the purpose of working several of the blocks, is erecting a concentrating plant in Bangalore in order to raise the percentage of Cr_2O_3 up to about 50.[1]

Singhbhum. In 1907 a specimen found by Mr. R. Saubolle, prospecting on behalf of Martin & Co. of Calcutta, near the Suru pass on the road from Chaibasa to Sonua, Bengal-Nagpur Railway, in the Singhbhum district, Bengal, proved on examination in the Geological Survey Office to be chromite. The ore occurs as bed-like veins and as scattered granules in serpentine. A sample taken from a total of about 10 tons of ore extracted from twelve prospecting pits showed 50·05 per cent. of Cr_2O_3, and a picked specimen 53·19 per cent. Prospecting operations on this and two other occurrences in the immediate vicinity have not as yet disclosed any large bodies of ore, but only irregular veins. Some 400 tons of unclean ore have been extracted during 1909.

Coal.

Progress in output. Since the year 1882 the expansion in the coal mining industry has been uninterrupted and during the past eight years the production has been doubled, while during the quinquennial period under review activity in coal-mining became marked to such an extent as to constitute what might well be called a 'boom,' for the demand so far kept ahead of the supply that the average prices obtained during 1908 were higher than any previously recorded. The total production rose from 8,216,706 tons in 1904 to 12,769,635 tons in 1908, an

[1] Report, Chief Inspector of Mines, Mysore, for 1906-07, p. 38: also the report for 1907-08, p. 20.

increase of 55·4 per cent. The annual figures for production and value during the quinquennial period are shown in table 4.

TABLE 4.—*Production and Value of Coal during the years 1904 to 1908.*

YEAR.	Quantity.	Total value at the mines.		*Average value per ton at the mines.*			
	Tons.	Rs.	£	Rs.	A.	*s*	*d*
1904	8,216,706	2,09,82,407	**1,398,826**	2	9	*3*	*5*
1905 .	8,417,739	2,12,91,649	**1,419,443**	2	8	*3*	*4*
1906 .	9,783,250	2,86,80,655	**1,912,042**	2	15	*3*	*11*
1907	11,147,339	3,91,45,900	**2,609,726**	3	8	*4*	*8*
1908 .	12,769,635	5,03,43,130	**3,356,209**	3	15	*5*	*3*

It should be remembered that the values stated are, in reality, the prices paid for coal at the pit's mouth, and these are necessarily dependent upon the relation between local supply and demand, not indicative of the actual value of the fuel. Bengal coal, which is all round the best quality worked in India, is returned as having a lower value than the coal worked in other provinces, where higher prices can be safely demanded by the miner.

Prices.

The average cost of coal to the consumer in India is low compared to that of most of the principal coal-producing countries of the world. The following table shows the declared pit-mouth value in some other countries during the five years 1903 to 1907:—

Countries	Per ton.		Countries.	Per ton.	
	s.	*d.*		*s.*	*d.*
United Kingdom . .	7	7½	France (*a*) . .	11	0¼
United States	5	11¾	Australia	6	8¼
Germany	8	10¾	Japan	7	6½

(*a*) For 1903 to 1906 only.

Comparison of India with Canada and Australia.

In the previous review (page 18), it is related how the Indian coal production overtook that of Canada in 1896, and how it gradually approached that of Australia, until in the year 1902 the latter country also was overtaken; but it was anticipated that, owing to the growth of the iron and steel industries of Canada, which would lead to a large consumption of coal, India would soon have to resign to Canada the first place amongst the British dependencies as a coal producer. During the period under review, the Canadian production of pig-iron and steel continued to grow rapidly: in 1900, the total Canadian pig-iron production was 96,575 short tons, and the amount of rolled iron and steel 100,690 short tons, some of this being, of course, manufactured from imported pig-iron. By 1907, this production increased rapidly to 651,962 short tons of pig-iron and 706,982 short tons of steel. The production of both products in 1908 was slightly less than in 1907. But notwithstanding this considerable increase in the production of iron and steel in Canada, India has not fallen behind as a producer of coal during the period under review. On the contrary,

TABLE 5.—*Production of Coal in the three large British Dependencies.*

COUNTRIES.	1903.		1904.		1905.		1906.		1907.	
	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*
Australia .	7,229,182	*2·77*	7,252,785	*2·74*	7,616,248	*2·82*	8,734,368	*3·02*	9,836,453	*3·17*
Canada .	7,254,429	*2·78*	7,634,679	*2·88*	7,961,397	*2·94*	8,995,810	*3·11*	9,535,812	*3·07*
India .	7,557,754	*2·89*	8,348,561	*3·15*	8,552,422	*3·16*	9,940,247	*3·43*	11,325,696	*3·65*
TOTAL for British Empire	260,614,898	..	264,684,236	..	269,929,379	..	289,037,607	..	309,671,528	..

as will be seen by a reference to table 5, India has continued to increase, year by year, its lead over both Canada and Australia, this lead amounting by 1907 to 1,500,000 tons over Australia and 1,800,000 tons over Canada. The cause of this is doubtless to be

found in the greatly increased industrial activity of India during the period under review, leading not only to an increased consumption of coal in the producing industries, such as jute and cotton, but also to an increased consumption of coal on the railways engaged in the carriage of the products of India's industrial and agricultural activity; and as but a small proportion of the Indian coal is exported, this largely increased production may be regarded as an index of the increase in prosperity of India during the period considered. In 1902, the Indian output formed 2·95 per cent. of the total output of coal for the British Empire, and only 0·94 per cent. of the world's total output. By 1907, the Indian proportion had increased to 3·65 per cent. of the total for the British Empire, and 1·02 per cent. of the world's total output.

Comparison of India with Japan.

A serious competitor with India for the supply of coal to Ceylon, the Straits Settlements, Sumatra, and Java, is Japan; whilst, in the Pacific, Indian coal has, as a rule, little chance of competing on successful terms with the Japanese coal, owing mainly to questions of freight. Japan, also, is developing rapidly industrially, and therefore, in these circumstances, it is interesting to compare the production of coal in the two countries. A reference to table 6 will show that, in 1885, the Indian and Japanese productions were practically identical, *viz.*, a little under 1,300,000 tons. From thence onward the production of Japan has increased at a slightly greater rate than that of India. Thus, in 1900, the Indian production was a little over 6 million tons, and the Japanese over 7 million; in 1905, the Indian output was 8·4 million tons, and the Japanese 3 millions more. By 1908, the Indian output had increased to nearly 12·8 million tons, with the Japanese over 2 millions more. The coal exports of Japan, which by its position commands the ports of China, have risen to a much larger figure than those of India. The consequence is that the quantity of coal retained for consumption in Japan is approximately the same as the amount consumed in India, as will be seen by a comparison of the last column of table 6 with the figures given in table 7. In making this comparison, however, it must be remembered that a given consumption of coal in Japan registers a much greater proportional industrial activity than does the same consumption of India, on account of the much smaller population of the former country.

TABLE 6.—*Comparison of the Indian and Japanese Coal Statistics.*

YEAR.	PRODUCTION.		IMPORTS.		EXPORTS.		Quantity retained for consumption in Japan.
	India.	Japan.	India.	Japan.	India.	Japan.	
	Tons.	Tons.	Tons.	Tons.	Tons	Tons.	Tons.
1885 . .	1.294.221	1,294,000	790.930	12,876	750	191,802	1,115,074
1890 . .	2,168,521	2,566.551	784.664	12,301	26,649	853,720	1,725,132
1895 .	3,540,019	4,733.861	761.996	68.931	81,126	1.376.068	3,426,724
1900 .	6.118.692	7,369.068	127.318	108.593	541,453	2.402.785	5,074,876
1904 . .	8,216 706	10.599.710	252,393	626.711	594 850	2.878.503	8,347,918
1905 . .	8,417.739	11,407.799	179,935	329,495	836,188	2.507.527	9.229,767
1906 . .	9.783.250	13,043.874	257.203	34.525	935.580	2,402.354	10,676.045
1907 . .	11,147,339	13.716,488	308.348	18.461	728.916	2.922,190	10.812,459
1908 . .	12,769.635	14.825,363	455,806	30.640	571.621	2,863.116	11.992,887

Relation of consumption to production.

The market for Indian coal must be limited to (1) the home industries and (2) the Indian Ocean ports, where the manufacturing industries requiring coal are comparatively few, and where India is not the sole supplier of fuel. Tables 7 and 10 show that, during the past five years, India consumed on an average 92·6 per cent. of the coal produced in the country, and, in addition, imported annually on an average 256,821 tons of foreign coal. This compares with an average consumption during the previous period of 93·1 per cent. of the coal produced in the country, in addition to an annual import of 298,940 tons of foreign coal.

The actual annual increment of consumption since 1903 has been, on the average, 1,065,495 tons, whilst the increment of production during the same period has averaged 1,066,250 tons. This is, in each case, about double the rates of increment for the previous period. As the increments for consumption and production are so nearly alike, it is evident that the great expansion that has taken place in the Indian coal trade must be due, as already noted, to industrial developments in India itself. That it has little

to do with increased facilities of transport and of consequent access to new markets is shown by a reference to table 10, from which it will be seen that the increase in the Indian exports has been very small, the average annual exports for the five years (1903-04 to 1907-08) being only 721,408 tons as compared with 426,835 tons for the previous five fiscal years (1898-99 to 1902-03).

TABLE 7.—*Relation of Consumption to Production.* (*a*)

YEAR.	Total consumption of coal in India.	CONSUMPTION OF INDIAN COAL IN INDIA.	
		Quantity.	*Percentage of Indian production.*
	Tons.	Tons.	
1904	8,888,773	7,610,639	*92·6*
1905	8,848,306	7,630,686	*90·6*
1906	9,016,668	8,775,798	*89·7*
1907	10,801,484	10,484,020	*94·0*
1908	12,515,644	12,107,919	*94·8*
Average	*10,014,175*	*9,321,812*	*92·6*

(*a*) The consumption of coal is assumed to be production *plus* imports *minus* exports. In the imports and exports a ton of coke is taken to be equivalent to 2 tons of coal. The imports include Government stores.

Consumption of coal on Indian railways.

The quantity of coal consumed on the railways in India has steadily increased during the past quinquennial period as in the previous period reviewed. Ten years' ago, in 1899, the quantity of Indian coal consumed amounted to 1,557,000 tons, while last year, 1908, the consumption reached 3,604,094. Yet, the relation between the railway consumption of coal and that of the various industrial enterprises in the country keeps a very constant ratio. During the previous period reviewed the Indian coal consumed on the railways was on an average just 29·7 per cent. of

the total production, and exactly the same ratio holds for the quinquennial period just past. The various industries of the country are thus maintaining their coal consuming capacity with the growth of railways, for the variations in exports and imports have been very slight indeed. The lesson to be drawn from this circumstance was pointed out in the previous Review: the general nature of the coal-consuming industries has not changed; there has been no development of the metallurgical industries within range of the coalfields, and unless these develop the demand for coal will increase only with the normal development of trade.

TABLE 8.—***Coal consumed on Indian Railways during the years 1904 to 1908.***

YEAR.	INDIAN COAL.			FOREIGN COAL.		Total consumption.
	Quantity.	*Per cent. of Total.*	Per cent. of Indian output	Quantity.	*Per cent. of Total.*	
	Tons.			Tons.		Tons.
1904 . . .	2,447,341	*99·3*	29·8	17,432	*0·7*	**2,464,773**
1905 . . .	2,668,424	*99·3*	31·7	18,235	*0·7*	**2,686,659**
1906 . . .	2,878,281	*98·7*	29·4	37,280	*1·3*	**2,915,561**
1907 . . .	3,343,219	*98·4*	29·9	54,861	*1·6*	**3,398,080**
1908 . . .	3,604,094	*97·9*	28·2	79,633	*2·1*	**3,683,727**
Average .	*2,988,272*	..	*29·7*	*41,488*	..	*3,029,760*

Foreign coal on Indian railways.

There was a tendency to purchase more foreign coal for consumption on some of the railways during 1907 and 1908, when prices were forced up and large quantities of second class coal were put on the market. The quantity of foreign coal consumed on the railways in 1908 was the highest recorded since 1899, when the amount taken was 82,446 tons. The variations during the past ten years have, however, been small compared to

the total coal consumption on the railways; foreign coal was rapidly displaced by the Indian product after 1888, when it amounted to 31 per cent. of the total. Since 1900 the Indian collieries have supplied about 98 per cent. or more of the total railway requirements, and the amount of foreign material now taken is due to local and chance variations in ocean freights.

Earnings from transport of coal.

The transport of coal forms an important item in the earnings of the Railway Companies, especially the East Indian and Bengal-Nagpur systems which serve the Raniganj, Jherria, Giridih, and Daltonganj fields. The traffic in coal for all Indian railways is shown in table 9. This table excludes coal carried by railways for their own consumption.

TABLE 9.—*Coal carried for the Public or Foreign Railways during the years 1903 to 1908.*

	Coal carried on Indian Railways.	Earning of Railways from coal traffic.
	Millions of Tons.	£, Millions.
1903	8·56	1·54
1904	9·40	1·71
1905	10·20	1·93
1906	11·19	2·15
1907	12·19	2·12
1908	13·24	2·39

Imports and exports.

Table 10 shows the relation between the imports of foreign coal and the exports of Indian coal during the past ten years. It will be seen that there has been very little change in the total imports, while there has been on the whole a marked increase in the exports, the maximum having occurred in the year 1906-07, when the quantity of Indian coal exported exceeded 900,000 tons, while for the calendar year 1906 the exports were just over a million

tons. During 1907 and 1908, when there was such a marked increase in the industrial activity of India, exports were largely curtailed, while the demand for foreign coal increased in spite of the greatly increased production of coal in India. Previous to 1901 the imports of foreign coal always exceeded the exports, while ever since the balance has been reversed.

TABLE 10.—*Imports and Exports of Coal during the years 1898-99 to 1907-08, including Government stores.* (*a*)

YEAR.	Imports.	Exports.
	Tons.	Tons.
1898-99	**390,616**	327,430
1899-1900	**494,870**	305,189
1900-01	155,088	**544,100**
1901-02	294,945	**525,408**
1902-03	233,507	**432,850**
1903-04	212,982	**496,072**
1904-05	282,499	**598,208**
1905-06	192,147	**840,388**
1906-07	272,041	**939,312**
1907-08	324,435	**733,061**
Average	*285,373*	**574,122**

(*a*) The figures include coke and patent fuel, each ton of coke being reckoned as 2 tons of coal.

Imports.

Table 11 shews the origin of the coal imported during the past five years. The principal features of interest are the increased imports during the last year from Australia and Natal to meet the excessive demands of 1907, when the Indian collieries were unable to keep pace with the sudden increase in industrial activity, and prices were raised sufficiently to make importation profitable.

TABLE 11.—*Origin of Imported Coal, Coke, and Patent Fuel.*

YEAR.	United Kingdom.	Australia.	Natal.	Japan.	Other countries.	**Total.**
	Tons.	Tons.	Tons.	Tons.	Tons.	**Tons.**
1903-04 . .	162,474	25,046	1,118	16,424	1,767	**206,829**
1904-05 . .	199,861	10,746	3,595	55,443	5,560	**275,205**
1905-06 . .	144,701	6,259	15	27,862	8,074	**186,911**
1906-07 . .	227,158	25,873	75	4,505	4,675	**262,286**
1907-08 . .	216,597	50,290	35,349	5,288	2,301	**309,825**
Average .	*190,158*	*23,643*	*8,030*	*21,904*	*4,476*	*248,211*

The distribution of exported Indian coal is shown in table 12 from which it will be seen that Ceylon and the Straits remained as before the principal customers, both having increased their demands. During the

Exports.

TABLE 12.—*Exports of Indian Coal.*

—	1903-04.	1904-05.	1905-06.	1906-07.	1907-08.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Aden . .	43,410	14,598	29,312	19,233	13,835	*24,077*
British East Africa.	19,642	7,162	..	3,700	2,850	*6,671*
Mauritius .	8,802	13,413	10,618	11,332	3,587	*9,550*
Ceylon . .	257,251	374,754	381,045	404,144	384,938	*360,427*
Java . .	3,842	6,115	8,171	14,953	6,600	*7,936*
Straits Settlements.	142,256	143,729	235,429	293,788	203,419	*203,724*
Sumatra . .	13,975	30,802	35,227	70,648	101,651	*50,461*
Hongkong .	..	..	126,069	100,711	..	*45,356*
Other countries	3,892	4,259	10,278	16,841	11,001	*9,254*
TOTAL, Exports	**493,070**	**594,832**	**836,149**	**935,350**	**727,881**	*717,456*
VALUE .	£ 254,172	£ 310,213	£ 436,568	£ 498,683	£ 393,047	£ 378,536

previous period reviewed Ceylon took on an average 246,352 tons of Indian coal a year, against an average of 360,427 tons in the past quinquennial period. At the same time the quantities shipped to the Straits Settlements rose from an average of 85,095 tons in 1897—1903 to an annual average of 203,724 tons in 1903—1908. Considerable quantities of coal were sent to Hongkong during 1905 and 1906 to meet the demand caused by cessation of exports from Japan.

Possible expansion of the export trade.

The two tables 13 and 14 show the extent of the two chief markets for which India has to compete with Australia, Japan, and Natal. The British coal taken in Ceylon and the Straits Settlements is not all in competition with Indian coal, for some of the mail steamers must accept the high quality of steaming fuel from England in spite of the comparatively low prices of material obtainable from India and the Pacific. The variations in the share which India takes in these markets is of little value as an index to the growth of the industry: the collieries have been barely able to meet the domestic demand, and Indian consumers complain no less than outside customers of the quantities of low-grade fuel forced on them during the past two years.

One cannot say that there is any prospect of India sending much coal to Pacific ports; although the principal competitors at present are Japan and Australia, and these two countries will find domestic markets for their coal in their own industrial developments. China, however, is known to possess large deposits, which will remain locked up until more perfect transport facilities are provided from the fields to the coast.

TABLE 13.—*Foreign Coal Imports of Ceylon for the years 1904 to 1908.*

ORIGIN OF THE COAL.	1904.	1905.	1906.	1907.	1908.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom.	308,208	215,382	332,253	294,714	266,539	*283,419*
British India .	300,538	362,696	337,668	293,559	383,269	*335,546*
Japan . .	32,389	31,875	8,206	18,969	15,398	*21,367*
Other countries	2,151	486	3,351	1,008	32,329	*7,865*
TOTAL, Imports	**643,286**	**610,439**	**681,478**	**608,250**	**697,535**	*648,197*

TABLE 14.— *Imports of Coal into the Straits Settlements for the years 1904 to 1908.*

ORIGIN OF THE COAL.	1904.	1905.	1906.	1907.	1908.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom.	42,979	66,785	90,362	84,895	37,288	*64.462*
British India .	125,613	205.057	323,207	209,055	101,578	*192,902*
Australia.	38,667	66,720	218,931	91.049	210.696	*125,212*
Japan . .	400,628	261,553	85,209	251,527	318,607	*263,503*
Other countries	11,892	41,115	41,219	38,906	73,884	*41,403*
TOTAL, Imports	**619,779**	**641,230**	**758,928**	**675,432**	**742,053**	*687,484*

Calcutta exports.

During the previous period reviewed the coal shipped from Calcutta to other Indian ports averaged nearly 1¼ million tons; during the past quinquennial period this average exceeded 2 million tons, and during the last year, 1908, the coal shipped from Calcutta to other parts of India reached just 2¼ million tons. For the distribution of this coal see table 15. The most marked change has been the extraordinary increase in the coal sent direct to Karachi, which formerly received much of its coal *viâ* Bombay. During 1908 over half a million tons of Bengal coal went to Karachi. Bombay remains the chief customer for Bengal coal, the annual demand being now steadily over one million tons. A notable increase has also been made in the case of Chittagong, where the demands of the Assam-Bengal Railway supplement the wants of consequently increased shipping. Rangoon has continued to expand with the rapid development of its oversea trade, and now takes over 100,000 tons more coal than was required annually before 1903.

TABLE 15.—*Distribution of Bengal Coal from Calcutta to Indian Ports during 1904-1908.*

PORTS.	1904.	1905.	1906.	1907.	1908.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Akyab	5,465	3,966	3,885	6,929	8,447	*5,738*
Bassein	..	15,372	10,641	5,550	11,030	*8,519*
Bhownagar	14,170	9,425	16,342	10,223	20,741	*14,180*
Bombay	796,554	1,013,169	1,152,976	1,002,712	1,058,759	*1,004,834*
Chandbali	619	684	654	491	322	*554*
Chittagong	4,911	4,172	3,482	6,587	12,585	*6,347*
Coconada	6,135	344	5,363	..	2,600	*2,889*
Cuddalore	30,024	48,907	25,478	50,009	56,014	*42,086*
Karachi	245,918	365,301	383,862	399,247	579,654	*394,796*
Mandapam	29,074	7,232	22,777	19,750	22,620	*20,291*
Madras	221,035	99,947	139,686	281,202	274,876	*203,349*
Mormugao	33,350	26,878	22,319	32,550	26,164	*28,252*
Moulmein	1,835	2,199	217	5,062	2,203	*2,303*
Negapatam	30,234	27,149	28,118	19,560	34,499	*27,912*
Pondicherry	8,788	2,620	4,309	3,375	4,704	*4,760*
Port Blair	2,699	6,030	4,900	4,898	5,354	*4,776*
Rangoon	287,356	347,404	372,282	363,351	360,831	*346,245*
Tuticorin	15,269	11,862	12,441	12,551	18,176	*14,060*
Other ports	930	6,044	3,630	11,483	392	*4,496*
TOTAL	1,734,366	1,998,705	2,213,362	2,235,530	2,499,971	*2,136,387*

Table 16 shows the provincial production for the years 1904 to 1908. It will be seen that Bengal, which yields Gondwana coal only, increased

Provincial production.

TABLE 16.—*Output of Indian Coal by Provinces for the years 1904 to 1908.*

PROVINCE.	1904.	1905.	1906.	1907.	1908.	TOTAL.
	Tons.	Tons.	Tons.	Tons	Tons.	Tons.
Baluchistan .	49,867	41,725	42,164	42,488	45,212	221,456
Bengal . .	7,063,680	7,234,103	8,617,820	9,903,348	11,559,911	44,468,862
Burma . .	1,105	..	1,222	..	..	2,327
Central India .	185,774	157,701	170,292	178,588	155,107	847,462
Central Provinces	139,027	147,265	92,848	134,088	213,789	727,017
Eastern Bengal and Assam .	266,765	277,065	285,490	295,795	275,224	1,400,339
Hyderabad	419,546	454,294	467,923	414,221	444,211	2,200,195
Kashmir . .	270				..	270
North-West Frontier Province .	..	.			90	90
Punjab .	45,594	62,622	73,119	60,749	54,794	296,878
Rajputana (Bikanir) .	45,078	42,964	32,372	28,062	21,297	169,773
TOTAL	8,216,706	8,417,739	9,783,250	11,147,339	12,769,635	50,334,669

its output from a little over 7 million tons in 1904 to 11½ million tons in 1908. Among the other provinces. Baluchistan shows no pronounced change since 1903. In the following year the production reached nearly 50,000 tons, and then fell back to between 41,000 and 45,000 tons. The production recorded for Central India is entirely that due to the Umaria collieries, where there have been small ups and downs during the past ten years without any marked change in one direction. In the Central Provinces, where the production varied for many years between 140,000 and 190,000 tons, there was a sudden drop in 1906, due to the closing down of the Warora colliery, only partially compensated by increased activity in the Pench Valley area and at Mohpani. The rapid rise during the last two years of the period is due largely to increased production in the Pench Valley field, but partly also to the development of new collieries at Bellarpur in the Chanda district. The production of Eastern Bengal and Assam is nearly all due to the coal mines in the neighbourhood of Margherita in the Lakhimpur district

of North-East Assam. The production in this area reached its maximum in 1907, but is limited mainly by the difficulties due to working inclines in thick seams liable to spontaneous combustion. The production recorded for Hyderabad is due to the mines at Singareni, which have maintained an average output of a little over 400,000 tons for the last ten years. There has been no noteworthy change in the production of the Punjab, where the only coal obtained is from the mines in the Tertiary rocks of the Salt Range area. The production recorded for Rajputana is that of the Palana colliery in the Bikanir State. The maximum production of this colliery occurred in 1904, when 45,000 tons were obtained. Since then there has been a noticeable drop in the output, largely due to the fact that areas of the coal-seam having got on fire, the whole system of underground working has been recently undergoing reorganisation.

Geological Relations of Indian Coal.

The Gondwana system.

The formations from which 96 per cent. of the coal supplies of India is obtained was named the *Gonduana* system by H. B. Medlicott in 1872.[1] It is[2] 'chiefly composed of sandstones and shales, which, except for some exposures along the east coast, appear to have been entirely deposited in fresh water, and probably by rivers.'

The lowest division of the system is known as the *Talchir* series from its original discovery in the small state of this name in Orissa.[3] The beds of this series are of small thickness; but they are known and, from their peculiar features, easily recognised in most of the coalfields. They include boulder-beds supposed to be due to glacial action, and are thus regarded as similar in origin, probably also corresponding in geological age, to the Dwyka formation which lies at the base of the similar coal-bearing Karoo system in South Africa.

1 F. Stoliczka, *Rec. Geol. Surv. Ind.*, IX, p. 28, (1876); and *cf. Rec. Geol. Surv. Ind.*, XIV, p. ii, (1881).

2 R. D. Oldham, Manual, Geol. Ind., 2nd Ed., p. 149, (1893).

3 T. Oldham, *Mem. Geol. Surv. Ind.* I, p. 46, (1856).

The only section of the Gondwana system which is important from the coal-producing point of view is that distinguished as the *Damuda* series.[1] from its development in the valley of the Damuda river. In the Raniganj and Jherria fields this series can be subdivided into three stages, of which that distinguished as the *Barakar* below and that known as the *Raniganj* stage above the *Ironstone shales* both include valuable coal-seams. The Raniganj stage produces the principal part of the supplies obtained from the Raniganj field; but seams in this stage of the Jherria field are generally thinner and poorer than those in the Barakar stage.

Age of the Lower Gondwana coal-measures.

The absence of marine formations throughout the lower division of the Gondwana system made it impossible at first to determine with any precision the geological age of the coal-measures with reference to the recognised standard stratigraphical scale of Europe. The geologists who first separated the Talchirs from the overlying strata of the Gondwanas, regarded them on slender indirect evidence as probably not more recent than Permian in age.[2] On account of the affinities of the plant remains in the Lower Gondwanas, they were regarded as Triassic in age, while the Rajmahal beds in the Upper Gondwanas were considered to be Jurassic.[3] A reconsideration of the fossil evidence and comparison with similar beds associated with marine formations in Australia tended to confirm the earlier conclusions regarding the Palæozoic age of the Lower Gondwanas.[4] The recent discovery of typical Lower Gondwana plant remains embedded in marine formations in Kashmir, where they were deposited probably near the mouth of one of the great rivers flowing from Gondwanaland into the great ocean then covering the area now occupied by Central Asia, confirms the conclusion regarding the Palæozoic age of the Lower Gondwanas: these Gondwana plants have been found in beds that are certainly not younger than Upper Carboniferous.[5] Thus, the Indian coal-measures are not

[1] T. Oldham, *Journ. As. Soc., Bengal*, XXV, p. 253, (1856).

[2] W. T. and H. F. Blanford and W. Theobald, *Mem. Geol. Surv. Ind.*, I, p. 82, (1859).

[3] O. Feistmantel, *Rec. Geol. Surv. Ind.*, IX, p. 79, (1876).

[4] See recapitulation by W. T. Blanford, *Rec. Geol. Surv. Ind.*, IX, pp. 79—85, (1876).

[5] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXVI, p. 38, (1907).

much younger than, and may even be of the same age as, those of Europe.

Although there are coal-seams in the Jurassic rocks of Cutch and in the Cretaceous beds of Assam, all the coal being worked outside the Gondwana fields is of Tertiary age.

Eocene coal: Palana.

At Palana in the Bikanir State, Rajputana, a lignitic coal containing small nodules of resin lies immediately underneath Nummulitic limestones,[1] from which characteristic Lutetian (middle eocene) fossils have been obtained.[2]

Tertiary coal in Assam.

Coal of the same age is being worked in the Punjab and Baluchistan, while some of that worked on a small scale in the Khasi and Jaintia hills of Assam is also associated with Nummulitic rocks. The thick seams of the Lakhimpur district, which yield most of the coal now mined in Assam, belong to a series of beds whose age is not determinable by direct evidence, as they have not been found in contact with any fossiliferous marine formations. The same series yields the petroleum of the Digboi area, and because of this circumstance together with the fact that the overlying sandstones resemble the Pliocene Irrawaddy series overlying the Miocene oil-bearing strata in Upper Burma, there is a temptation naturally to regard the Lakhimpur coal and associated petroliferous beds as Miocene in age.

Some of the small coal basins on the Assam plateau are said to be of Cretaceous age, the coal in these basins being always characterised by containing lumps of fossil resin like those found in the Palana lignite.

Geological origin of the coal.

Table 17 shows the origin of the coal produced during the years 1904 to 1908. It will be noticed that the output from the Gondwana coalfields, which averaged 95·85 per cent. of the total production, has gradually become a larger fraction of the total. In 1904, 95·02 per cent. of the coal was obtained from the Gondwana fields, and 4·98 per cent. from Tertiary beds, while in 1908, 96·9 per cent. of the total belonged to the former category and 3·1 per

1 T. D. LaTouche. *Rec. Geol. Surv. Ind.*, XXX, pp 122—125, (1897).
2 E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVI, p. 314, (1907).

cent. only was Tertiary coal. The increase in the production of Gondwana coal was mainly due to the extraordinary activity which characterised the Bengal coalfields during 1907 and 1908.

TABLE 17.—*Origin of Indian Coal raised during the years 1904 to 1908.*

YEAR.	FROM GONDWANA STRATA.		FROM TERTIARY STRATA.		TOTAL Production.
	Tons.	*Per cent. of Total.*	Tons.	*Per cent. of Total.*	Tons.
1904 . .	7,808,027	*95·02*	408,679	*4·98*	**8,216,706**
1905 . .	7,993,363	*94·95*	424,376	*5·05*	**8,417,739**
1906 . .	9,348,883	*95·56*	434,367	*4·44*	**9,783,250**
1907 . .	10,720,245	*96·17*	427,094	*3·83*	**11,147,339**
1908 . .	12,373,018	*96·90*	396,617	*3·10*	**12,769,635**
Average . .	*9,648,707*	*95·85*	*418,226*	*4·15*	**10,066,933**

The Gondwana coalfields.

During the previous period reviewed, the contribution from the Gondwana coalfields rose from 93·4 to 95·1 per cent. of the Indian total. During the past quinquennial period this percentage rose to nearly 97, due to great activity in Bengal, and especially to the rapid development of the Jherria coalfield. When the last Review of Mineral Production was issued, the Raniganj field was still the leading field in India, and it maintained its lead up to the year 1905. In 1906, however, Jherria went ahead of Raniganj, and in the two succeeding years increased its lead, for in 1908 the Jherria field yielded just one-half of the total production in India, while Raniganj produced one-third of the total (see fig. 8, p. 47). The figures of production from the Gondwana coalfields are shown in table 18.

TABLE 18.—*Output of Gondwana Coalfields for the years 1904 to 1908.*

COALFIELD.	1904.		1905.		1906.		1907.		1908.	
	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*
Bengal—										
Daltonganj	50,517	·61	71,294	·85	86,768	·89	81,873	·73	96,391	·76
Giridih	773,128	9·41	829,271	9·85	803,321	8·21	750,374	6·73	782,763	6·13
Jherria	2,889,504	35·17	3,070,588	36·48	4,076,591	41·67	5,179,185	46·47	6,458,643	50·58
Rajmahal	274	..	414	..	577	..	257	..	333	..
Raniganj	3,350,257	40·77	3,262,536	38·77	3,650,563	37·32	3,981,659	35·72	4,221,781	33·06
Central India—										
Umaria	185,774	2·26	157,701	1·87	170,292	1·74	178,588	1·60	155,107	1·22
Central Provinces—										
Bellarpur	90	..	148	·02	916	·34	18,103	·16	45,299	·35
Pench Valley	..	..	1,104		32,102		74,663	·67	120,249	·94
Mohpani	26,618	·32	22,998	·27	27,503	·28	41,322	·37	48,241	·38
Warora	112,319	1·37	123,015	1·46	32,327	·33	..	..	..	..
Hyderabad—										
Singareni	419,546	5·11	454,294	5·38	467,924	4·78	414,221	3·72	444,211	3·48
TOTAL Gondwana beds	**7,808,027**	95·02	**7,993,363**	94·95	**9,248,884**	95·56	**10,728,245**	96·17	**12,373,018**	96·90

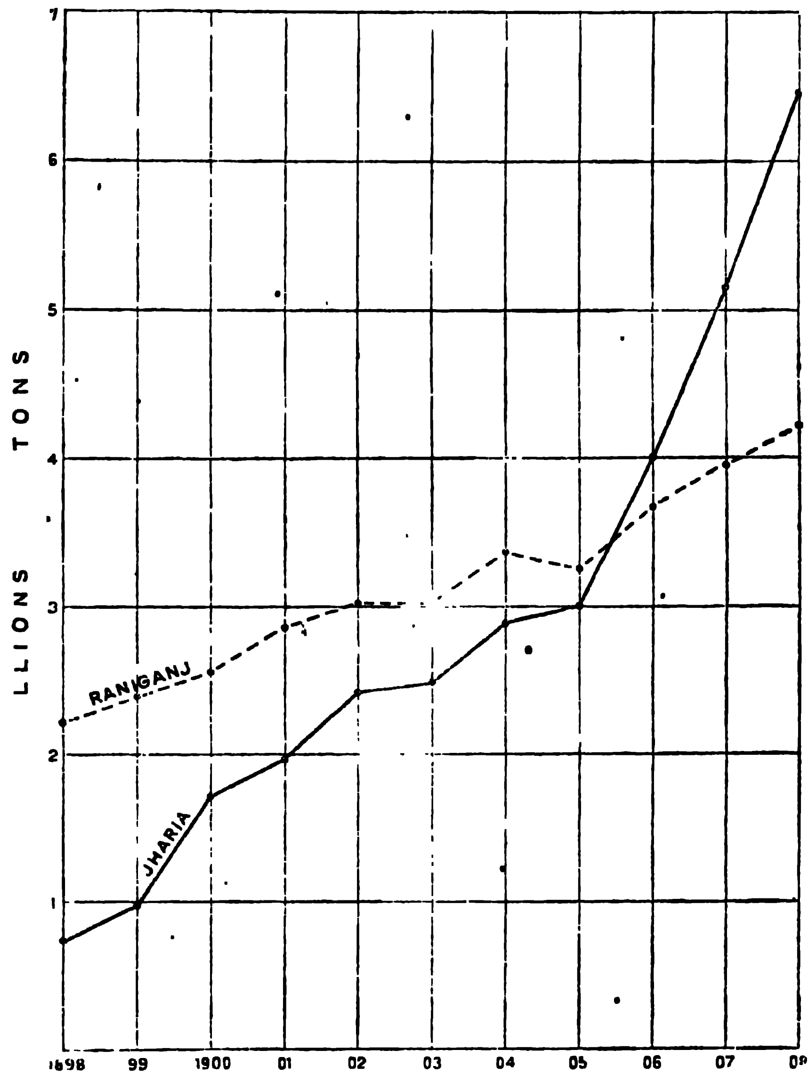


FIG. 8.– *Production of Coal in the Raniganj and Jharia fields, 1898-1908.*

Distributions of the Gondwana fields.

The Gondwana coals have been preserved on the eastern part of the Peninsula by being faulted down into the Archæan basement complex; but either the faulting or the softness of the Gondwana rocks has determined the direction of the Damuda, Mahanadi, and Godavari valleys in which the

principal fields are found. In the Central Provinces the Gondwana rocks form the Mahadeva or Mahadeo Hills, a portion of the Satpura hill-range, which stands up above the general peneplain of the Peninsula.

The fields which have been worked to any extent include the Raniganj and Jherria fields in the Damuda valley; the Giridih field occurring as a small isolated patch to the north of the Damuda valley; the Daltonganj field, further west, in the Palamau district; the Singareni, Bellarpur, and Warora fields in the Godavari valley; the Mohpani and Pench Valley fields lying respectively at the northern and southern fringes of the Satpura range. Before the great depressions now occupied by the Indus, Ganges and Brahmaputra were formed, the Gondwanas probably stretched in great sheets of sandstones, shales and coals as far north as the area now occupied by the Outer Himalaya, and fragments of the strata, caught up in the Himalayan folds, are now preserved near Darjeeling, in Bhutan, and in North Assam. The coal in these extra-Peninsular patches of Gondwana rocks has been damaged by crushing, but prospecting operations in the Darjeeling district have shown that there is much valuable fuel obtainable in this area.[1]

The north-west ends of the Godavari and Mahanadi belts of coalfields have been overwhelmed by the great sheets of Deccan trap, and no one knows, consequently, how much coal lies hidden under this mantle in the Central Provinces and Berar.

Raniganj field.

The Raniganj field covers an area of about 500 square miles, most of it within the civil district of Burdwan, but stretching also across the boundaries into Bankura, Manbhum, and the Santhal Parganas. The field was surveyed in 1858-60 by W. T. Blanford and his map, published on a scale of one inch to a mile,[2] has been the recognised guide to the colliery managers. Additional detail regarding seams discovered during subsequent mining operations have been added by Dr. W. Saise and Mr. G. A. Stonier to a map published by the *Colliery Guardian*,[3] and a map has been prepared, but not published, by Babu Baidyanath Saha showing the distribution of the dykes of basalt and mica-peridotite which

[1] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXIV, p. 212. (1891).
[2] With *Mem. Geol. Surv. Ind.*, Vol. III, Part 1.
[3] Supplement: Feb. 10th, 1905, p. 21.

traverse the field in great numbers. Recently a Committee of the Mining and Geological Institute of India has been formed to undertake the revision of the geological map on a scale of four inches to a mile, and Mr. H. Walker of the Geological Survey has been on special duty during the seasons 1908-09 and 1909-10 compiling the results obtainable from the mine-plans.

The sub-divisions of the Gondwanas represented on the field are :—

3. *Panchets.*
2. *Damudas* :—
   c. Raniganj stage.
   b. Ironstone shales.
   a. Barakar stage.
1. *Talchirs.*

There is a general dip to the south and south-east throughout the field, and consequently the Talchirs are exposed as a band along the northern margin, succeeded by the younger formations towards the south. As the beds dipping to the south-east are overlapped by the alluvium of the Damuda valley, the distance to which the coal-bearing rocks extend in this direction towards Burdwan and Calcutta is unknown. In order to test the field in this direction a boring was put down by the East Indian Railway Company in the years 1903 to 1906 at Durgapur, 16 miles south-east of Raniganj, but to the depth of just 3,000 feet the only rocks penetrated were those of the Panchet series and perhaps upper part of the Raniganj stage. At this point, therefore, the coal-seams are buried to a greater depth than 3,000 feet. As the Damuda river stretches away to the south-east in an almost straight line for a distance of about 45 miles beyond the Raniganj field, and thus runs approximately parallel to some great faults within the field, it is possible that its alignment is determined by a great dip-fault, and the Gondwana strata possibly continue along the left bank of the river far beyond the visible limits of the field. Although the Durgapur boring shows that the coal-seams are at that point more than 3,000 feet below the surface, it is quite possible that the depressing effects of the general south-easterly dip may be neutralised by strike faults. Whether the coal measures are brought up in this way to within workable distance of the surface in the south-east direction, or whether they are

now hopelessly beyond reach (if they ever were developed in this area), can only be determined by trial borings to the south-east of Durgapur. So long as there are abundant supplies nearer the surface in the Raniganj and Jherria fields, it will be to no one's financial advantage to risk the money required to test this interesting question.

The information at present available for publication regarding the quality of the coal being worked in the Raniganj field is comparatively limited, for the correlation of the various seams being worked in the different collieries is still doubtful. We are indebted to Dr. W. Saise for a series of assays published in 1904[1] These show the following extremes and averages —

TABLE 19 —*Assays of Coal from the Raniganj field* (*W. Saise*)

		Moisture.	Ash	Volatile Matter	Fixed Carbon
RANIGANJ (Upper Seams).	Highest	9·05		38·53	60·50
	Lowest	4·60	8·00	26·40	32·40
	Average of 11 assays	*6·86*	*14·93*	*32·22*	*45·99*
RANIGANJ (Lower Seams)	Highest	6·20	22·50	38·2	61·00
	Lowest	1·50	8·84	27·00	46·00
	Average of 28 assays	*3·81*	*13·54*	*31·40*	*51·25*
BARAKAR SEAMS	Highest	1·50	25·00	29·25	61·00
	Lowest	0·50	11·00	23·75	49·00
	Average of 8 assays	*1·00*	*17·00*	*26·75*	*55·25*

With variations so wide among the samples these assays are too few to give reliable averages; but they show that the older Barakar seams constantly differ from those of the Raniganj stage in containing less moisture, and generally differ by having a smaller percentage of volatile hydrocarbons. The same difference has been noticed in the corresponding stages in the Jherria field. The

1 *Rec. Geol Surv Ind.*, XXXI, p. 104.

higher seams of the Raniganj stage also differ from those below by containing generally more moisture and volatile matter with less fixed carbon.

Jherria field.

In the Jherria field the only Gondwana formations preserved are the Talchirs and the three divisions of the Damuda series—the Barakars, Ironstone shales, and Raniganjs. The Barakars are by far the most important to the coal-miner, and no attempts were made to work the thinner and poorer seams of the Raniganj series until the 'boom' of 1906-07 led to the opening up of every tolerable seam of coal within range of the two railway systems that serve the field.

During 1903 a number of coal samples from the Barakar seams were taken by Messrs. E. P. Martin and H. Louis at the working faces in some leading mines in this field. The average of fifteen assays made on these samples was as follows :—

Fixed carbon .	. 63·50
Volatile matter .	. 21·31
Ash . .	. 14·29
Moisture . .	. 0·90

Ten of these were tested for sulphur and were found to contain on an average 0·57 per cent., while the same ten samples showed an average evaporative power of 12·82 lbs. of water per lb. of coal.

The Jherria field, like that of Raniganj and Giridih, is traversed by trap-dykes, the most destructive being a peculiar form of mica-peridotite,[1] which spreads out as sheets in the coal-seams destroying large quantities of valuable coal. The seams known as Nos. 14 and 15, which otherwise include a high quality of coal, are especially damaged by trap intrusions in the centre and east of the field.

The Barakars form a crescent-shaped outcrop along the north and east boundaries of the field, the seams of coal being numbered

[1] Holland, *Rec. Geol. Surv. Ind.*, XXVII, pp. 129—141, (1894).

from the margin inwards from 1 to 18. Small faults occur in most parts of the field, but generally in the north and east there is little disturbance and the seams, which dip inwards at gentle angles to the south and west, can be followed with fair confidence; but the south-east corner is considerably faulted, the seams generally dip at greater angles, and the correlation of the seams worked in this area with those numbered in the rest of the field is often a matter of conjecture.

The field was first mapped and described by the late T. W. H. Hughes [*Mem. Geol. Surv. Ind.*, Vol. V, part 3, (1866)]. Certain additions and corrections were made after further examination by T. H. Ward in 1890 (*Rec. Geol. Surv. Ind.*, XXV, page 110), and Mr. Ward's map, with further additions by G. A. Stonier, was republished by the *Colliery Guardian* in 1904 (Supplement, September 16, page 5).

Bokaro and Ramgarh fields.

Few important developments have occurred recently in the other Bengal fields. A company has been formed to take up land in the Bokaro and Ramgarh coalfields lying immediately to the west of Jherria in the Damuda valley. It is proposed to share the land with the two railway companies—East Indian and Bengal-Nagpur—who will construct branch lines to serve the field.

Bye-product recovery on the Giridih field.

In the last Review (p. 30) reference was made to the proposed erection of bye-product recovery ovens on the Giridih field. The first battery of eighteen ovens of the Simon Carvès type was ready for work at the end of March 1909, and an extension of twelve more ovens is now nearly ready. The products recovered are tar and ammonia, the latter being converted into ammonium sulphate. The first trial shows a recovery of 54 lbs. of tar and 11·47 lbs. of sulphate per ton of coal coked, but this outturn will probably be improved with practice. The tar is of excellent quality and finds a ready market in Calcutta. The sulphate gives the following average analysis:—

Total Ammonia (NH_3)	25·066 per cent.
Moisture	1·42 ,,

For want of a local demand this product is being exported to Java for consumption on the sugar plantations.

The sulphuric acid used is manufactured at Konnagar near Calcutta from imported sulphur by Messrs. D. Waldie & Co., who are

also recovering in the same way the ammonia in the waste liquors from the Calcutta Gas Works.

Other fields.

The other principal coalfields being worked in the Peninsula are Mohpani, the Pench Valley, and Bellarpur, in the Central Provinces, Umaria in the Rewah State, and Singareni in the Nizam's Dominions. Of these Bellarpur has been opened up during the period of the present Review, to take the place of the Warora colliery, which was closed down in 1906.

Warora.

In the preceding Review (p. 33) reference was made to the failing resources of the Warora colliery which was at the time expected to last only another three or four years. The end was, however, determined in March 1906, when, after a serious subsidence affecting about 15 acres of the principal workings, it was decided that further work would not be remunerative or safe. Coal was raised for another month from one of the unaffected pits, and work was finally stopped on the 30th April, 1906. For some years before the abandonment of the collieries, work had been limited to the extraction of pillars, and in any case the work would have been abandoned within the year. Altogether, since the Warora colliery was commenced in 1871, the coal raised amounted to 3,086,220 tons, most of the coal originally proved to exist having been lost by underground fires.

The working of the colliery resulted in a financial loss up to 1882, but after that year there was a gradual improvement, the final result being a net balance of Rs. 17,97,506. Table 20 summarises the results of the last five years' work. The average cost of a ton of coal during the last five years was Rs. 3-2-5 (4*s.* 2½*d.*), while the average selling price was Rs. 4-7-7 (5*s.* 11¼*d.*). Both figures are slightly higher than the corresponding averages for the six years previously reviewed. An analysis of the working expenses was given in the previous Review (page 32).

Table 21 shows the labour statistics at Warora for the last five years of its exploitation. The output per person employed shows on an average a lower result than in previous years; but in spite of the special dangers the accidents were comparatively rare, there

TABLE 20.—*Financial Results of the Warora Collieries for the last five years of its existence.*

Year.	Gross earnings.	Working expenses.	Financial result. Net profit.	Per cent. on capital expenditure.
	Rs.	Rs.	Rs.	
1902-03	6,02,271	4,44,808	2,47,983	16·24
1903-04	5,51,786	3,81,009	1,70,777	11·58
1904-05	5,46,464	3,74,287	1,72,177	12·32
1905-06	5,52,398	3,57,042	1,95,356	15·05
1906-07	23,231	45,507	*—22,276*	*—1·74*

being only four deaths in five years among an average of 1,343 workers employed daily.

The production of fire-bricks contributed a small amount to the revenue when the mine was being worked, but the fire-clay bed was necessarily abandoned with the remainder of the coal.

TABLE 21.—*Labour Statistics for the last five years of the Warora Colliery.*

—	Output of coal.	Average number employed daily.	*Production per person employed.*	Deaths from accidents.	*Deaths per 1,000 employed.*
	Tons.		*Tons.*		
1901-02	150,427	1,586	*94·8*	1	*0·63*
1902-03	150,339	1,521	*98·9*	—	..
1903-04	116,901	1,409	*83·0*	1	*0·71*
1904-05	114,718	1,199	*95·7*	2	*1·67*
1905-06	118,402	999	*118·5*	..	..
Average .	*130,157*	*1,343*	*96·9*	*0·8*	*0·60*

In anticipation of the failure of Warora prospecting operations were undertaken by Government at Bellarpur, 38 miles to the south-south-east in the Chanda district, on the left bank of the Wardha river. Coal was proved by borings over an area of 1½ square miles and a shaft was commenced. The large quantities of water met with in sinking proved to be a formidable obstacle, as all fuel used for the pumping engines had to be carried by road from Warora. Bellarpur was joined to the Great Indian Peninsula system by an extension of the Wardha-Warora branch, which was opened for traffic on the 1st February 1908. Meanwhile two 14-foot circular shafts had been sunk to the coal at depths of 257 feet (No. 1) and 236 feet (No. 2), and in 1906 a small quantity of coal was raised for use on the railway construction works. One of the shafts is lined with brick and ferro-concrete, and the other with fire-bricks moulded to the circle of the shaft.

Bellarpur.

The seam is 50 feet thick, including thin partings of shale; but the only part at present being worked is an 8-foot layer in the middle of the seam. The workings are on the bord-and-pillar system, the pillars left being 60 feet square. At present the output is about 300 tons a day, but arrangements are made to develop to about 600-700 tons a day.

The prospecting operations and subsequent development were conducted by Mr. R. Wordsworth while still Manager of Warora, and he has now transferred his headquarters to Bellarpur.

During the financial year 1907-08 the coal raised at Bellarpur amounted to 23,127 tons. The expenditure incurred amounted to Rs. 68,110, and income from sales amounted to Rs. 98,330, the net profit amounting to 4·8 per cent. on the capital expenditure of Rs. 6,29,941 incurred since the commencement of operations.

The coal at Bellarpur, like most of that obtained from the Gondwanas of the Central Provinces, contains a large proportion of moisture, and also shows inclusions of pyrites. The following two assays were made in the Geological Survey Laboratory on samples obtained when the seam was being first opened up:—

Moisture	11·10	13·51
Volatile Matter	31·56	30·61
Fixed Carbon	45·47	45·21
Ash	11·87	10·67
	100·00	100·00

Pench Valley.

Since the last Review was issued the Pench Valley field in the Chhindwara district has been opened up, and production has risen from 1,104 tons in 1905 to 120,249 tons in 1908. The Bengal-Nagpur Railway narrow-gauge branch line reached the field in 1906, and the Chandametta colliery was opened. There is one haulage incline from which about 8,000 tons are drawn monthly, and a separate travelling road, while a shaft, of 15 feet diameter, is down to 200 feet and will be deepened to 300 feet.

The coal is harder than in Bengal · it is undercut by hand, hewers being paid on the Lancashire kirving system, and each hewer takes a bord on which he is paid by measurement made weekly. The shot-firers and putters are paid also on work done, while the onsetters of the tubs and the banksmen and pit carpenters are on daily pay.

At the Buteria colliery there is one incline and one shaft at present, 60 feet deep, while at the Barkui mine there is one main haulage incline and an upcast shaft of 60 feet. In this area the coal, 7 feet thick, is of better quality than that at Buteria or Chandametta.

The coal is all screened to dust, nuts and steam coal over the railway cars. An experimental coal-cutting plant of the Siskol type has been installed, and has given promising results.

Captain F. I. L. Ditmas, late General Manager of these collieries, has introduced a system of training young men, on behalf of the Central Provinces Administration, to be foremen and ultimately Assistant Managers, and the experiment promises encouraging results.

In addition to the work commenced by the Pench Valley Coal Company, development on a smaller scale has been attempted by the Upper Pench Coal Company, the Pench River Coal Company, the Pench Consolidated Coal Company, and the Central Pench Coal Company. These Companies have taken up portions of the land originally held by the chief Company, and most probably await a broad-gauge direct connection with the main railway systems before development on any large scale can occur.

The average number of persons employed daily during the years

1905 to 1908 was 515; this, with five deaths, gives a death-rate of 2·43 per 1,000. The annual figures are:—

1905	104 persons.
1906	228 ,,
1907	511 ,,
1908	1,217 ,,

Bazargaon, Nagpur.

Boring operations have recently been undertaken by the Pench Valley Coal Company under prospecting licenses on the inlier of Kamthi rocks north of Bazargaon and about 16 miles west of Nagpur. This area was described by W. T. Blanford in *Memoirs, Geol. Surv. India*, Vol. IX, part 2, page 314. No definite evidence was obtainable as to the existence of. coal in this area, although W. T. Blanford in a letter dated 12th of February 1867 [*Rec. Geol. Surv. India*, Vol. I, page 26, (1868)], suggested that the area might be worth testing by borings on the off-chance of coal accompanying the Gondwana rocks. It is said that fragments of coal and carbonaceous shale have been found recently in wells, and consequently interest has again been aroused in the occurrence. The borings now being put down are undertaken with this possibility in view.

Mohpani.

The oldest colliery in the Central Provinces is Mohpani. The Mohpani coalfield is situated in the Narsinghpur district on the south side of the Nerbudda alluvial valley, and at the foot of the northern spurs of the Satpuras. The divisions of the Gondwana system exposed in this field are the Mahadevas, the Barakars, and the Talchirs, the known coal-seams lying. as usual, in the Barakars. About forty years ago, the Sitariva Coal Company carried out a certain amount of work on the field, but the actual development of the Mohpani coalfield is due to the efforts of the Nerbudda Coal and Iron Company, Ltd., which commenced operations in 1862, and, from then until 1904, spent more than £150,000 on the undertaking. The mines are divided into the old field and the new field. The *old field* was abandoned in 1902 after practically the whole of the coal workable to the existing shafts had been won, the total amount so extracted being 450,845 tons, the deepest shaft being the Helen pit, 405 feet deep, and the number of coal-seams four.

The *new field*, forming part of a second concession adjoining the old field, was first opened up in 1892, and up to the end of 1903 the Company had raised 181,080 tons of coal and splint from the two upper coal-seams. As in the old workings on the Sitariva river, faulting and heavy water discharge were, in 1903, giving considerable trouble; so that, in order satisfactorily to work out the already proved coal, additional capital was necessary for hauling and pumping plant. This capital the shareholders of the Nerbudda Coal and Iron Company were unwilling to supply. On the other hand, the Great Indian Peninsula Railway Company, to whose system the mines are connected by a ten-mile branch line to Gadarwada, and who had been taking the output of the Mohpani Collieries at a uniform rate of Rs. 6 a ton, was dissatisfied with the small output; consequently, after a report by Mr. R. R. Simpson of the Geological Survey of India, the properties were sold to the Great Indian Peninsula Railway Company for £40,000 with effect from the 1st July 1904. The results of the change are seen in the rapidly increasing output of this colliery, which sunk as low as 26,618 tons in 1904 and 22,998 in 1905 but rose to 48,241 tons in 1908 (see table 18).

In the course of his examination of the field, Mr. Simpson made estimates as to the quantity of coal still left to be extracted, and he came to the conclusion that the amount of coal and splint proved by the workings was 1,610,379 tons of coal in Nos. 1 and 2 seams and 411,076 tons of splint in No. 1 seam. In addition to these, he estimated that 725,081 tons could safely be assumed as obtainable from Nos. 3 and 4 seams, and that an additional quantity of 4,833,902 tons of coal could reasonably be assumed to be obtainable from seams Nos. 1 to 4 and the upper and lower seams of the 1895 area, together with 426,018 tons of splint from No. 1 seam. The grand total thus estimated to be available is 7,169,362 tons of coal and 837,094 tons of splint. In making these estimates, Mr. Simpson has assumed an extraction of two-thirds of the coal worked. The thicknesses of the four seams are:—

No. 1 seam	11 feet of coal with an intermediate band of 6 feet of splint, the specific gravities of coal and splint averaging 1·48 an 1·70 respectively.
„ 2 „	25 feet.
„ 3 „	5 feet.
„ 4 „	6½ feet.

In the 1895 area, the thicknesses are taken as—

Upper seam	18 feet,
Lower seams	9 feet,

the extraction assumed for this area being 50 per cent. In addition, it is considered possible that a considerable quantity of coal may eventually be found in the old field to the dip of the Helen pit at a considerable but by no means unworkable depth; but, to prove this, boring will be necessary.

While examining the field Mr. Simpson took ten average samples of coal from seams Nos. 1 and 2 and one sample of the splint in seam No. 1. In 1908, Mr. F. L. G. Simpson, who has been Manager of the Mohpani Collieries since 1882, took a series of twelve samples of coal representing all the four seams (one of them being of the splint) for the purposes of the Nagpur Exhibition. These samples were subjected to approximate analyses in the Geological Survey Laboratory. In table 22 below are given the extremes and means of these twenty-one analyses of coal and of two analyses[1] of splint; and also an average of thirty-nine assays of Bengal coal, taken from Mr. R. R. Simpson's report. Speaking generally, the coal is somewhat inferior to the average of Bengal coals. Mr. R. R. Simpson quotes figures for recent trials on the Great Indian Peninsula Railway showing the following values:—

Sanctoria (Bengal)	1·00
Singareni . .	1·18
Mohpani . .	1·32
Warora . .	1·57
Umaria . .	1·62

Sanctoria coal is distinctly superior to the average Bengal coal, and it can be taken that $1\frac{1}{4}$ tons of Mohpani coal are equal to one ton of average Bengal coal.

1 Some of these, together with some ultimate analyses and coke assays of Mohpani coal by Mr. C. S. Fawcitt of Bangalore, and a complete analysis of ash from No. 1 bottom seam, also by Mr. Fawcitt, are given in the report (L. L. Fermor and J. Kellerschon) on the Mining Section of the Central Provinces Exhibition in *Trans. Min. Geol. Inst. Ind.*, IV, pp. 134 and 135, (1909).

TABLE 22.—*Assays of Coal from the Mohpani Field.*

		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calorific value in heat units (C).	Evaporative value in lbs. of water.
MR. R. R. SIMPSON'S SAMPLES (1904).	Highest	4·60	32·04	57·54	35·98			
	Lowest	1·28	17·86	39·50	15·50			
	Average of 10 assays.		*24·51*	*48·96*	*24·01*			
	Splint	2·84	21·02	37·90	38·24			
MR. F. L. G. SIMPSON'S SAMPLES (1908).	Highest	5·97	34·20	53·03	22·94	0·79	7,187	13·38
	Lowest	4·06	25·65	43·96	9·79	0·23	5,573	10·38
	Average of 11 assays	*5·28*	*29·81*	*48·34*	*16·57*	*0·37*	*6,427*	*11·97*
	Splint	3·68	23·06	31·94	41·32	0·85	4,400	8·19
BENGAL COAL-FIELDS.	*Average of 39 assays.*		31·30	53·70	15·00			

The average number of persons employed daily at Mohpani during the period under review was 868, the annual figures being as follows :—

1904	664
1905	680
1906	790
1907	979
1908	1,227
Average	*868*

The number of deaths was two, giving an average death-rate for the period of 0·46 per 1,000, a very low figure.

Singareni.

The great belt of Gondwana rocks, near the north-west end of which Warora is situated, stretches down the Godavari valley as far as Rajamundry, and at one or two places the equivalents of the coal-bearing Damuda

series in Bengal are found cropping up from below the Upper Gondwana rocks. One of these occurrences near Yellandu in the Nizam's Dominions forms the coalfield well known by the name of Singareni. The principal seam of coal, some 5 to 6 feet thick, being worked at the Singareni colliery, was discovered by the late Dr. W. King of the Geological Survey in 1872, but mining operations were not commenced until 1886, since when the output has rapidly risen to over 400,000 tons a year. It has fluctuated between this figure and 470,000 ever since 1899, except in 1903, when there was a decline to 362,733 tons, owing to a serious subsidence in one of the workings (see table 18 and plate 2).

Coal-mining at Singareni has been accompanied by a heavier loss of life by accidents than in the general run of Gondwana fields. Table 23 shows the death-rate on this field compared with the rate in Bengal. The average figure for the five years 1904 to 1908 (1·55 per 1,000) is, however, a little lower than that for the period of the previous review (1·87 per 1,000).

TABLE 23.—*Death-rate from Accidents at Singareni compared with Bengal.*

	—	1904.	1905.	1906.	1907.	1908.	*Average.*
SINGARENI	Number of persons employed	8,742	7,666	7,296	7,868	7,047	*7,724*
	Deaths from accidents	11	11	18	10	11	*12*
	Death-rate per 1,000 employed	1·25	1·43	2·46	1·27	1·56	*1·55*
Death-rate in Bengal coalfields		0·59	0·60	0·76	0·76	1·11	*0·80*

Umaria.

The Bilaspur-Katni branch of the Bengal-Nagpur Railway passes through the small coalfield of Umaria in the Rewah State, Central India. The quantity of workable coal in this field is estimated at about 24,000,000 tons. During the period of the previous review a gradual increase of output was recorded from 134,726 tons in 1898 to 193,277 tons in 1903, the average for the five years (1899-1903) being about 172,000 tons. During the period now under

review, the output has fluctuated somewhat, the average figure being nearly 170,000 tons per annum (see table 18). The fluctuations in the output of this colliery are the result of the varying demands of the Great Indian Peninsula Railway which takes a very large proportion of the total output; the stoppage in the increase is due to the fact that this railway is now able to obtain an increasing supply from Mohpani, and also to draw on the Pench Valley mines. The Bengal-Nagpur Railway, which formerly took a small portion of the Umaria output, has ceased its demands during the last year or two. The three coal-seams being worked vary from about 3 to 12 feet in thickness and dip at about 4° to the north-east. The mines were opened in 1882 under the direction of Mr. T. W. H. Hughes of the Geological Survey and were controlled by Government until the 1st January 1900, when they were handed over to the Rewah State, to which they are a source of considerable profit, the annual net earnings during the period under review amounting to about Rs. 2,50,000, except in the year 1908-09, when the earnings fell to about Rs. 1,50,000.

The average number of persons employed daily at Umaria during the period under review was 1,713, the figures for each year being as follows:—

1904	1,859
1905	1,690
1906	1,546
1907	1,710
1908	1,762
Average	*1,713*

The number of deaths was 3, giving an average death-rate for the period of 0·35 per 1,000 employed.

Bhutan.

In the foot-hills of Bhutan[1] coal has been found near the Kala Pani as highly-inclined crushed lenticular seams near the junction of the enclosing Gondwana rocks with the Siwaliks, which is marked by a reversed fault. The coal is of poor quality, friable, and does not seem

[1] G. E. Pilgrim, *Rec. Geol. Surv. Ind.*, XXXIV, pp. 31—36, (1900).

to occur in any large quantity, the total length of outcrop at the principal locality being 900 feet, and the average total thickness not more than 12 feet.

Tertiary Coalfields.

As has already been noted (see page 44), all the coal being worked outside the Gondwana coalfields is of Tertiary age. Coal of this age is found in Baluchistan, Sind, Rajputana, the Punjab, along the foot-hills of the Himalayas, further east in Assam, in Burma, and in the Andaman and Nicobar Islands. The most frequent occurrence is in association with nummulitic limestones (Eocene), although the richest deposits, *viz.*, those in North-East Assam, are younger, probably Miocene, in age. The output from each of these Tertiary fields for the years 1904 to 1908 is shown in table 24. From this table it will be seen that the output of Tertiary coal during the period under review now averages over 400,000 tons a year as compared with an average of about 342,000 tons a year during the period previously reviewed. This increase is due to a considerably larger output from the Makum field in Assam, from the Khost field in Baluchistan, and the Palana field in Bikanir, offset slightly by a nearly complete stoppage of the output of coal from Burma.

On the whole, the younger coals, which are being worked in extra-Peninsular areas, differ from the Gondwana coals in containing a larger proportion of moisture and volatile hydrocarbons, and though as variable in composition as they are in thickness of seam, coals are obtained, as for instance in Assam, with a remarkably low percentage of ash and having a high calorific value. The high proportion of moisture in some of these younger coals is, however, often a serious cause of deficiency in calorific value. The difference between the Tertiary coals and Gondwana coal from Bengal is well seen in the following table, which gives the extremes and averages of analyses of five samples of coal from Assam, two from Baluchistan, one from Burma, and five from the Punjab, given in a paper on the "Composition and Quality of Indian Coals" by Professor W. R. Dunstan[1]; and also the average of thirty-nine samples of Bengal coal by Mr. R. R. Simpson, given on page 60.

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 241-253, (1906). The results tabulated in this paper are supplementary to those given in the *Indian Agricultural Ledger*, (No. 14, 1898), and *Journ. Soc. Arts*, L, pp. 371-407, (1902).

TABLE 24.—*Production of Tertiary Coal during the years 1904 to 1908.*

COALFIELD.	1904		1905		1906		1907		1908	
	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*
***Baluchistan*—**										
Khost	38,574	*·47*	34,140	*·41*	32,500	*·33*	29,378	*·26*	31,547	*·25*
Sor Range, Mach, etc.	11,293	*·14*	7,585	*·09*	9,664	*·10*	13,116	*·12*	13,665	*·10*
***Burma*—**										
Shwebo	1,105	*·02*	..	..	..	..	..		..	
Upper Chindwin	..		..	..	1,222	*·01*	..	..	..	..
***Kashmir*—**										..
Ladda	270		..	..	..	..	..	..	..	
***Eastern Bengal and Assam*—**										..
Makum	266,265	*3·25*	276,577	*3·29*	285,402	*2·92*	295,695	*2·65*	275,224	*2·15*
Smaller fields	500		488		88		100		..	
***North-West Frontier Province*—**										..
Hazara	..	..	..	..	..	..	..	..	90	*·43*
***Punjab*—**										
Salt Range	45,258	*·55*	61,618	*·75*	57,438	*·75*	47,298	*·55*	41,407	
Attock district	336		715		10		..		..	
Shahpur „	..		289		15,671		12,686		12,685	
Mianwali „	..		..		..		765		702	
***Rajputana*—**										
Bikanir	45,078	*·55*	42,964	*·51*	32,372	*·33*	28,062	*·25*	21,297	*·17*
Total	**408,679**	*4·98*	**424,376**	*5·05*	**434,367**	*4·44*	**427,094**	*3·83*	**396,617**	*3·10*

TABLE 25.—*Average Assays of Tertiary and Gondwana (Bengal) Coals.*

		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calorific value in heat units (C).	Evaporative value in lbs. of water.
Tertiary: higher grade: Assam and Baluchistan	Highest	5·83	46·48	53·28	9·56	4·87	7,702	14·34
	Lowest	1·45	40·42	41·50	1·27	0·74	6,028	11·22
	Average of 7 assays	*3·19*	*43·58*	*48·99*	*4·24*	*3·14*	*6,926*	*12·90*
Tertiary: lower grade: Burma and Punjab	Highest	10·85	47·08	39·44	39·91	4·41	6,730	12·53
	Lowest	3·47	26·85	27·79	8·50	0·33	4,270	7·95
	Average of 6 assays	*6·76*	*38·89*	*34·57*	*19·98*	*1·91*	*5,610*	*10·45*
Bengal coal-fields	*Average of 39 assays.*	..	*31·30*	*53·70*	*15·00*	..	..	..

North-East Assam.

The most promising amongst these young coals is the group of occurrences in North-East Assam, one of which is now being worked by the Assam Railways and Trading Company, which commenced operations at Makum (27° 15′; 95° 45′) in 1881. The collieries are connected by a metre-gauge railway with Dibrugarh on the Brahmaputra river, which being navigable forms both a market and a means of transport for the coal. The coal-bearing rocks to which the Makum field belongs stretch for 40 miles to the north-east, and can be traced for 100 miles to the south-west, along the northern front of the Patkai range. The most valuable seams occur between the Tirap and Namdang streams, where, for a distance of about 5 miles, the seams vary from 15 to 75 feet in thickness. Near Margherita, where the collieries are

situated, the average thickness of the thickest seam now being worked is about 50 feet of coal, with intercalations of fire-clay amounting to 10 feet; and in the Namdang section it increases to as much as 80 feet, and is persistent, with little variation, for a distance of 6 miles. The average dip is 40°; but as the outcrops in many places are several hundred feet above the plains, facilities exist for working the coal by adit levels. The average coal production of the Makum mines during the last five years has been 279,833 tons a year, as compared with 227,523 tons during the previous period. The coal has the reputation of being a good fuel. and forms an excellent coke. Mr. R. R. Simpson has sampled the coal-seams being worked in the Upper Ledo and Tikak mines in this field.[1]

The average compositions given by three samples from the Upper Ledo Colliery and representing an aggregate thickness of 49 feet, and five samples from the Tikak Colliery representing an aggregate thickness of 47 feet, are shown below:—

	Upper Ledo.	Tikak.
Moisture	1·80	2·09
Volatile hydrocarbons	40·15	37·25
Fixed carbon	55·59	58·99
Ash	2·46	1·67
Total .	100·00	100·00

Mr. Simpson[2] has also examined the Jaipur and Nazira coal-fields lying to the south-west of the Makum field.

He confirms the estimate previously made by Mr. Mallet with regard to the large quantity of good fuel in these two fields; in addition to the estimates of coal that can be proved, there is the probability of larger quantities hidden by the alluvial deposits; but in many places the seams are highly inclined, and, being below the level of permanent saturation, will be difficult to work except with special precautions to deal with the water. The most promising mining proposition is in the neighbourhood of the Dikhu river, where 2¼ million tons of coal would be certainly obtainable, the chief

[1] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 239-241, (1906).
[2] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 199-238, (1906).

difficulty to be overcome in this case being transport. The quality of the coals from these two fields is shown by a series of analyses (*l. c.*, pages 227—230), which are summarised below. The sulphur in five of the Jaipur coals averaged 1·87 per cent., and in five of the Nazira coals 3·35 per cent.

TABLE 26.—*Assays of Coal from the Jaipur and Nazira Coalfields.*

—		Moisture.	Volatile matter.	Fixed carbon.	Ash.
JAIPUR FIELD	Highest .	10·31	45·10	53·71	18·18
	Lowest . . .	3·95	35·49	41·38	1·10
	Average of 25 assays	*6·42*	*39·80*	*48·78*	*4·82*
NAZIRA FIELD	Highest . .	7·23	42·90	54·64	14·45
	Lowest . .	2·89	34·36	45·49	2·22
	Average of 12 assays	*5·49*	*38·11*	*50·04*	*6·36*

Burma.

Coal occurs in various parts of Burma, but the only district from which there has been any regular output of coal is the Shwebo district, from which there were returns varying between 6,975 and 13,302 tons during the period of the previous review. In February 1904, with the closing of the Letkopin mines, however, this district ceased to be a producer, and since that year the only output from Burma has been 1,222 tons of coal obtained in 1906 in the Upper Chhindwin district during prospecting operations.

Accounts have been published, however, of the previously known fields near Lashio[1] and Namma and of two new fields near Mansang and Man-se-le.[2]

1 T. D. LaTouche and R. R. Simpson, *Rec. Geol. Surv. Ind.*, XXXIII, pp. 117—124, (1906).

2 R. R. Simpson, *Rec. Geol. Surv. Ind.*, XXXIII, pp. 125—156; see also pp. 86—88.

All the four fields are situated in the Northern Shan States, and form an isolated basin lying on the prevalent Plateau limestones, and consist of sand, shale, and lignitic coal, probably of Pliocene age. In all these fields the coal is lignitic containing large quantities of moisture (10 to 23 per cent.), very low percentages of fixed carbon (9 to 40 per cent.), with very variable, often very high, quantities of ash. The best lignite seems to be that of the Namma field, but the cost of mining, briquetting, and transport of this fuel is more than its present value; it might be possible economically to briquette Lashio fuel, when it would be of service on the railway as far west as Maymyo.

Baluchistan: Khost.

Possibly the most important of the coal deposits in the west occur in Baluchistan, where, however, the disturbed state of the rocks renders mining operations difficult, expensive, and often dangerous. Besides the small mines being worked in the Sor range, south-east of Quetta, and in the Bolan pass at Mach, collieries have been worked since 1877 at Khost (30° 12′; 67° 40′) on the Sind-Pishin Railway. The two seams being worked have an average thickness respectively of 26 and 27 inches. During the period of the previous review, the output increased from 10,662 tons in 1898 to 36,444 in 1903. During the present quinquennial period, the output has averaged 33,228, the maximum being 38,574 tons in 1904 This consists mainly of steam and dust coal, with a small proportion of nut. Most of the dust coal is converted into pressed fuel, the quantity so manufactured averaging 14,000 to 15,000 tons a year. This is sold at Rs. 12 to Rs. 17 per ton, the price of the steam coal being Rs. 10-8 to Rs. 18-2.

During the first two years of the period under review, work was carried on at a profit at these collieries, which are under the control of the North-Western State Railway, whilst, during the last three years, the work has resulted in a loss (see table 27). This period, therefore, compares unfavourably with the previous one, when there was almost uniformly a considerable net profit. The output per person employed at Khost has averaged only 46 tons per annum during the period, and although the death-rate (10·9 per thousand) is much less than in the period previously reviewed (23·2 per thousand), yet it is abnormally high. Part of this abnormally high rate is due to an accident at the Nadir Khan mine,

where twenty miners were killed owing to an explosion of fire-damp on the 16th June 1908.

Besides the stratigraphical difficulties arising from working Tertiary coal-seams, which are often irregular in thickness and lie in disturbed, uncertain ground, there are additional dangers due to the liability of most of these pyritous coals to spontaneous combustion, and to the danger of explosion by the large quantities of dust generally formed in working such friable coals. To these natural difficulties is added a serious scarcity of trained labour.

TABLE 27.—*Summary of the Financial Results of working the Khost Colliery during the years 1904 to 1908.*

YEAR.	Gross earnings.	Working expenses.	FINANCIAL RESULT.	
			Net earnings.	*Percentage on capital.*
	£	£	£	
1904	22,817	20,425	2,122	*11·16*
1905	20,096	19,536	560	*2·75*
1906	18,211	19,692	—1,451	..
1907	16,469	19,181	—2,715	..
1908	18,986	21,284	—2,298	..

Punjab: Dandot.

The coal that has been most worked in the Punjab is that long known to exist in the Jhelum district, on the Dandot plateau of the Salt Range. The only available seam varies in thickness from 18 to 39 inches, forming a basin under the nummulitic limestones. The mines at Dandot and at Pidh, 3 miles to the north-east, have been worked for the North-Western Railway since 1884. During the period under review, the output from these collieries has

fluctuated between 41,407 tons in 1908 and 61,618 tons in 1905, the average figure being 50,604 tons a year. This is considerably less than the output during the period previously reviewed, and, during the whole of the present quinquennium, the mines have been worked at a loss, except in 1905, when there was a small profit. The annual output of coal per miner employed at Dandot during the last five years has averaged only 30 tons against about 101 tons turned out per man in Bengal; but notwithstanding the difficulties connected with mining in this area, the loss of life through accidents has been as low, on an average, as 0·71 per thousand employés.

Punjab: Shahpur district.

Coal-seams, similar to those of Dandot and Bhaganwala in the Jhelum district, are known to occur further west in the Shahpur district, the principal localities being Tejuwala near the crest of the southern scarp of the Salt Range, 12½ miles slightly west of north from Dhak on the Sind-Sagar branch of the North-Western Railway, and at Jhakarkot, 3½ miles south-west of Tejuwala. A small amount of work was prosecuted in 1890, but abandoned after the extraction of a few hundred tons of coal. Work was commenced on these deposits by Messrs. Bhagwan Das and Ram Das in 1905, and, during the three succeeding years, some 40,000 tons of coal have been won. The seam of coal being worked at these two places is of variable thickness, but averages perhaps 3 feet. As at Dandot, the coal-seam is being worked by means of drifts from the outcrop, a wasteful method of work, by which only the coal lying near the edges of a field are won. The quality of the coal is similar to that of Dandot, as is shown by the two analyses below, which represent samples taken by Mr. LaTouche. The total quantity of coal in both areas may be about 1,250,000 tons, but borings will be necessary to confirm this figure.

	Tejuwala.	Jhakarkot.
Moisture	5·08	7·60
Volatile matter	31·01	35·66
Fixed carbon	37·31	46·50
Ash	26·60	10·24
	100·00	100·00

Rajputana: Palana.

Mining operations on the lignite of Palana in the Bikanir State, Rajputana (see page 44), were commenced in 1898 at a point where the seam was found to be 20 feet thick, and a branch line, 10 miles long, to the Jodhpur-Bikanir Railway, has been constructed for a systematic development of the colliery. On account of the uncertainty regarding the horizontal extensions of the seam, the output is restricted. Thus, whilst the returns for the previous review show an increase in output from 9,250 tons in 1900 to 21,764 tons in 1903, the figures for the period now under review decrease continuously from 45,078 tons in 1904 to 21,297 tons in 1908. The physical characters of the natural fuel form a drawback to its use in locomotives; but during December 1908 and January 1909, important trials have been made with briquettes manufactured (by pressure only) in Germany from Palana coal, proving that the coal in briquette-form will be a valuable factor for locomotive work in the future. The proportion of moisture is reduced, and the fuel made less susceptible to atmospheric action. Briquetting plant cannot, however, be erected until the coal output at the mines has been increased—a matter now being taken in hand.

Labour.

Coal-mining, from the point of view of labour, still remains by far the most important of all forms of mining in India. During the period previously reviewed the average number of persons employed daily was 84,805, but in 1908 the returns showed a total of 129,173. Earlier figures were probably in excess of the actuals, and are now by no means perfect, but the administration of the Mines Act by the Inspectors has resulted in a greatly increased precision in the returns, and it is probable that the totals now fairly represent the employment afforded by the coal-mining industry. The provincial distribution of labour is shown in table 28, from which it will be seen that the share taken by Bengal has again increased, over 84 per cent. of the Indian colliery workers being employed in this province.

Efficiency of the Indian collier.

Attention was directed in the previous review to the low efficiency of the Indian coal-miner compared with that of the collier in most other countries. Part of this apparent low efficiency

has been due to the simplicity of the shallow mining operations, permitting the use of simple cheap labour with little machinery.

Table 28.—*Number of Persons employed in Indian Coal-Mining during the years 1904 to 1908.*

Province.	1904.	1905.	1906.	1907.	1908.	*Average.*	Per cent. of average total.
Baluchistan . .	1,072	1,082	982	1,044	1,069	*1,050*	1·00
Bengal . . .	75,804	74,072	82,885	96,301	112,219	*88,256*	84·29
Burma . . .	94	..	41	..	..	*27*	·02
Central India .	1,859	1,690	1,516	1,710	1,762	*1,713*	1·64
Central Provinces .	1,803	1,763	1,880	1,819	2,900	*2,033*	1·94
Eastern Bengal and Assam . .	1,339	1,549	1,849	1,731	1,709	*1,637*	1·56
Hyderabad . .	8,742	7,666	7,296	7,868	7,047	*7,724*	7·38
North-West Frontier Province . .	..	..	..	..	14	*3*	..
Punjab . . .	1,945	2,031	2,522	1,794	2,196	*2,097*	2·00
Rajputana . .	82	142	137	235	257	*171*	·17
Total .	**92,740**	**89,995**	**99,138**	**112,502**	**129,173**	*104,709*	100·00

The strings of coolie women carrying out coal along the inclines formed the most prominent feature of the fields in the old days. These are now naturally giving way to well-equipped installations for haulage, both through inclines and shafts. Table 29 shows that although there has been a greater output per person employed during the past quinquennial period than that shown by the returns for 1898-1903, there has been only a slightly increased efficiency during the past five years. This apparently slow improvement is partly due to the fact that little change has occurred in the numbers of workers required at the surface. The increased use of machinery with the deepening and extension of the mines shows up more distinctly in table 30, which gives the output of coal

per person employed below ground. During the past five years this output has increased from 126·4 to 153·5 tons per person employed below ground.

TABLE 29.—*Output of Coal per Person employed at Indian Mines during the years 1904 to 1908.*

YEAR.	Average daily attendance of workers.	Output.	*Output per person employed.*
		Tons.	*Tons.*
1904	92,740	8,216,706	*88·6*
1905	89,995	8,417,739	*93·5*
1906 . . .	99,138	9,783,250	*98·6*
1907 . , .	112,502	11,147,339	*99·1*
1908	129,173	12,769,635	*98·8*

TABLE 30.—*Output of Coal per Person employed Below Ground during the years 1904 to 1908.*

YEAR.	Average number of persons employed daily below ground.	Output.	*Output per person employed below ground.*
		Tons.	*Tons.*
1904	64,969	8,216,706	*126·4*
1905	61,616	8,417,739	*136·6*
1906	67,456	9,783,250	*145·0*
1907	73,191	11,147,339	*152·3*
1908	83,164	12,769,635	*153·5*

Table 31 shows how the efficiency of the Indian worker compares with that of the collier in other parts of the British Empire; but it should be remembered that this is not a true index of personal efficiency: in countries where labour is more expensive, and where mining operations are necessarily conducted at greater depths, the use of machinery becomes imperative.

TABLE 31.—*Amount of Coal raised per Person employed at Coal Mines in the British Empire.*

COUNTRIES.	1905.			1906.		
	Persons employed.	Tons of coal raised.	Tons per person.	Persons employed.	Tons of coal raised.	Tons per person.
United Kingdom	843,418	236,128,936	279·9	867,152	251,067,628	289·5
Australia (*a*) .	16,442	7,443,963	452·7	17,263	8,543,520	494·9
Canada (*b*) .	15,187	6,434,732	423·7	16,928	7,765,681	458·7
Cape Colony	2,445	146,529	59·9	1,956	127,569	65·2
Natal . .	5,650	1,129,407	199·8	6,059	1,238,713	204·4
New Zealand .	3,269	1,585,756	485·0	3,692	1,729,536	468·4
Orange River .	943	147,000	155·8	1,269	338,502	266·7
Transvaal .	8,988	2,327,499	258·9	9,445	2,582,504	273·1
British Empire, except India .	**896,342**	**255,343,322**	**284·8**	**923,764**	**273,393,653**	**295·9**
India . .	89,995	8,417,739	93·5	99,138	9,783,250	98·6

(*a*) Excluding Tasmania, which produced 52,827 tons of coal in 1905 and 53,745 tons in 1906.

(*b*) Represents British Columbia and Nova Scotia only.

We are indebted to Mr. J. R. R. Wilson, Chief Inspector of Mines, for the following note on the use of coal-cutting machinery and electricity in Bengal:—

Coal-cutting machinery and electricity.

Coal-cutting machinery makes headway but slowly, and opinions are much divided upon its actual utility. The principal forms of machines in use in other countries are the disc, rotary bar and percussive coal-cutters. Owing to the nature and thickness of the seams in Bengal the disc or the bar machine is not applicable unless the methods of working are radically altered. The question is worth very serious consideration as to whether many of the thick coals could not be mined in sections, and the cutting done entirely by machinery. A drawback to such a method is the scarcity of timber for prop wood, though, possibly, if a demand were created, the supply could be organised upon economical lines; and as an alternative some form of iron prop might be devised. At one mine in Bengal, where the seam is thin and the roof suitable, almost the whole of the coal is being mined by the long-wall method by compressed air disc machines. These machines are holing in the coal to a depth of 5 feet 6 inches, and, though under European supervision, are being handled with very considerable skill by native workmen. After being undercut, the coal is blasted down. The timbering on the face is systematically carried out, and the roof weights come on regularly in the goaf or waste and little timber is lost. The miners have quite adapted themselves to the change, and the system is an unqualified success.

Several firms are using the percussive form of coal cutter with more or less success, and there is actually one mine in the Raniganj coalfield where the whole of the output is obtained from these machines. This type of machine is used for both holing in the bottom or middle of the seam as the case may be, and shearing at the sides or centre; the coal is then blasted off by shots fired electrically. A few years ago the use of electricity was practically unknown in the coalfields; it is still in its infancy; but this source of power has been adopted at one or two mines, and some large installations are being put down for hauling, pumping, and lighting. Where there are scattered inclines upon a property, the adoption of electrical haulage should prove very economical. In this, as in so many other cases, the East Indian Railway Company's collieries have acted as pioneers.

The detailed description of the Equitable Coal Company's mines at Dishargarh, given by Mr. W. Miller in the *Transactions of the Mining and Geological Institute of India*, Vol. III, part 3 (1909), and the remarks thereon by Mr. W. C. Mountain in Vol. IV, part 2. will give a good idea of the equipment of one of the advanced types of collieries in Bengal.

Sanitation.

Coal-mining has developed so rapidly during the past few years in the Jherria and Raniganj fields that the mine managers, finding it necessary to spend their main energies in meeting the

demand for coal, have been able to spare little time and thought for the general well-being of the rapidly increasing community of workers. Commendable care has been exercised in individual cases to provide suitable accommodation for the miners, and filter installations have been erected to render the available water as nearly as possible innocuous; but there has been little or no combination of the Companies concerned to arrange for systematic sanitation and a sufficient or trustworthy water-supply for the whole community. The majority of workers are drawn from the aboriginal tribes, whose simple habits in sparsely inhabited jungles and cultivated areas are unsuitable to the more crowded conditions of industrial centres; they have yet to learn the value of sanitation and the advantages of the attempts made by the colliery owners to guard them from their new dangers. The disastrous epidemic of cholera, which resulted in about 5,000 deaths on the Jherria and Raniganj fields during the early months of 1908, impressed upon the owner as well as upon the worker the dangerous state of unstable equilibrium developed in the mining community. The subsequent drop in the demand for coal and consequent reduction in the feverish haste to increase the output has given the owner time to reconsider his methods of economising his mineral possessions and to give more thought to the equally important duty of looking after the health and happiness of his miners.

Death-rate from accidents.

Attention was directed in the previous review to the low average death-rate from accidents in Indian coal-mines. The average annual death-rate per 1,000 persons employed during the years 1898 to 1903 was 0·88, varying between 0·68 (1898) and 1·32 (1899). During the past quinquennial period the rate was slightly higher, working out to 0·98 per 1,000 for all Indian coal-mines, and varying between 0·72 in 1904 and 1·37 in 1908 (see table 32). Risks naturally increase with the deepening of the mines and general extension of the workings, while additional dangers may have been incurred by the haste to increase the output during periods of urgent demand for coal. The agreement of results with expectations may, however, be fortuitous, for the totals are so small that an isolated disaster, such as that which occurred at Khost in Baluchistan on the 16th June 1908, when twenty workers were killed, would have a disturbing effect on the average.

TABLE 32.—*Production of Coal compared with Deaths from Coal-Mining Accidents in India.*

——	1904	1905.	1906.	1907.	1908.	*Average.*
Deaths from coal-mining accidents	67	72	99	101	178	*103*
Thousands of tons of coal raised for each life lost .	122	116	98	110	71	*97*
Lives lost per million tons of coal raised . . .	8·1	8·5	10·1	9·0	13·9	*10·2*
Death-rate per thousand persons employed . . .	0·72	0·80	0·99	0·89	1·37	*0·98*

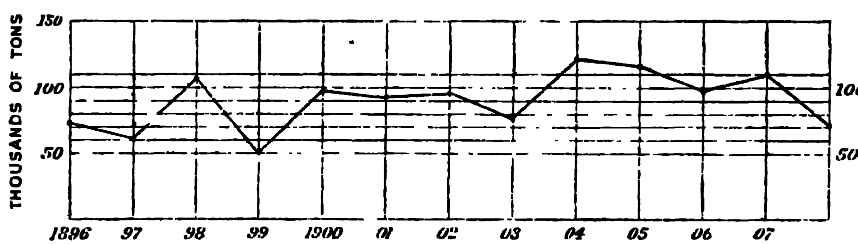


FIG. 9.—*Production of coal per life lost by coal-mining accidents.*

The coal mines, like all other mines, in British territory are worked under rules framed in accordance with the provisions of the Indian Mines Act (No. VIII of 1901), and are subject to constant official inspection. The Inspectors are also invited at times to inspect the mines being worked in Native States; and, although the returns from these latter show on an average a higher death-rate from accidents, it cannot be said that the difference is due to any differences in management, for the great number of mines in Bengal under the Act (which largely control the averages) are worked under exceptionally favourable conditions, while some of those in Native States, as for instance in Bikanir and Hyderabad, are exposed to special dangers. During the period

under review the average annual number of deaths from accidents at coal mines in Native States was 14, against 89 at mines under the Act, the death-rate being 1·45 per thousand in the former case against 0·93 per thousand at mines under the Act. The details for each year are given in table 33, from which it will be seen that, while there has been very little change in the labour returns and deaths at mines in Native States, there has been a great increase of employment at mines worked under the Act from a total of 80,496 in 1905 to 120,107 in 1908.

TABLE 33.—*Comparison of Death-rate from Accidents at Coal Mines worked under the Mines Act with those in Native States during 1904-1908.*

YEAR.	AVERAGE NUMBER OF PERSONS EMPLOYED DAILY.		DEATHS FROM ACCIDENTS.		DEATH-RATE PER 1,000 PERSONS EMPLOYED.	
	Mines under the Act.	*Native States.*	Mines under the Act.	*Native States.*	Mines under the Act.	*Native States.*
1904	82,057	*10,683*		*12*	0·67	*1·12*
1905	80,496	*9,498*	58	*14*	0·72	*1·47*
1906	90,159	*8,979*	80	*19*	0·88	*2·11*
1907	102,689	*9,813*	89	*12*	0·86	*1·22*
1908	120,107	*9,066*	165	*13*	1·37	*1·43*
Average	95,101	*9,608*	89	*14*	0·93	*1·45*

The returns for accidents at Indian coal mines are compared with those of other parts of the British Empire in table 34. As official returns for all other countries cannot be yet obtained for the year 1908, the comparison may be a little favourable to India by the exclusion of our worst year. However, the heavy results for 1908 are due to special causes which one may justifiably hope will not recur.

TABLE 34.—*Death-rate from Coal-Mining Accidents in the British Empire.*

Countries.	1905. Number employed.	1905. Death.	1905. Death-rate per 1,000.	1905. Deaths per 1,000,000 tons coal raised.	1906. Number employed.	1906. Deaths.	1906. Death-rate per 1,000.	1906. Deaths per 1,000,000 tons coal raised.
United Kingdom . .	843,418	1,138	*1·35*	4·74	867,152	1,116	*1·29*	4·37
Australia (*a*) .	16,442	27	*1·64*	3·62	17,263	21	*1·21*	2·45
Canada (*b*) .	15,187	32	*2·10*	4·97	16,928	43	*2·54*	5·53
Cape Colony	2,445	3	*1·23*	20·47	1,956	2	*1·02*	15·67
Natal . .	5,650	22	*3·54*	19·48	6,059	39	*5·95*	31·48
New Zealand	3,269	6	*1·84*	3·78	3,692	6	*1·63*	3·46
Orange River	943	..	..	..	1,269	..	..	..
Transvaal .	8,988	31	*3·45*	13·31	9,445	42	*4·45*	16·26
British Empire except India	**896,342**	**1,259**	**1·40**	**4·93**	**923,764**	**1,269**	**1·37**	**4·64**
India . .	89,995	72	*0·80*	8·55	99,138	99	*0·99*	10·12

(*a*) Excluding Tasmania.
(*b*) Represents British Columbia and Nova Scotia only.

A comparison of the accident returns for India with those of other parts of the British Empire brings out the fact that, while our death-rate is low per thousand employed, it looks less favourable when we consider the lives lost in raising a million tons of coal. This is due obviously to our low output per person employed. During the past five years we have lost by accidents on an average 10·2 lives per million tons of coal raised, while for the British Empire the loss is about half this rate. Still, it is perhaps not unfair to judge the risks incurred in an industry by the relation between the loss of life and the numbers who secure a comfortable

and, under Indian conditions, a fairly happy livelihood. On the whole, one cannot say that the life of the Indian collier, as compared with the collier of other countries, is an unhappy one, or that his occupation is specially 'dangerous.'

Diamonds.

Distribution in India.

Notwithstanding the reputation (stretching back even as far as Ptolemy in the European, and further in the Hindu, classics) which India has had as a diamond-producing country, the output of to-day is very small and comparatively unimportant. The places which, according to accounts, have been most productive in the past form three great groups, each in association with the old unfossiliferous rocks of probable pre-Cambrian age, now known as the Purana group, and distinguished locally as the Cuddapah and Kurnool systems in South India, and as the Vindhyan system in the northern part of the Peninsula.

Southern group of occurrences.

The southern of the three groups of diamond-occurrences includes localities, with apparently authentic records, in the districts of Cuddapah, Anantapur, Bellary, Kurnool, Kistna, and Godavari. Loose stones have been picked up on the surface of the ground, found in deposits of alluvium and in workings that have been undertaken in the so-called Banaganpalle stage of the Kurnool series of strata.

Eastern group of occurrences.

In the second group of occurrences, in the Mahanadi valley, the stones have been found in the alluvium of the Sambalpur and Chanda districts, but, though strata similar to those of the Vindhyans and Kurnools are known in this area, no diamonds have been found in these older rocks.

Central Indian occurrences.

The third group of occurrences occupies a tract some sixty miles long by ten miles wide, with the Vindhyan conglomerates near Panna as the centre. The diamond-mining industry still persists in this area, both in the old conglomerate of Vindhyan age, and in the alluvium derived therefrom. The States in which diamonds are found are Panna, Charkhari, Bijawar, Ajaigarh, Kothi, Pathar Kachhar and Chobepur.

The following scale of strata will give an idea of the position of the diamondiferous beds with reference to the Upper Vindhyan rocks exposed in the Central Indian area :—

BHANDER SERIES	Upper Bhander sandstone. Sirbu shales. Lower Bhander sandstone. Bhander limestone. Ganurgarh shale.

Diamondiferous horizon.

REWA SERIES	Upper Rewa sandstone. Jhiri shales. Lower Rewa sandstone. Panna shales.

Diamondiferous horizon.

KAIMUR SERIES	Upper Kaimur sandstone. Kaimur conglomerate. Bijaigarh shale. Lower Kaimur sandstone.

The following is a summary of the principal results of recent study, by Mr. E. Vredenburg,[1] of the diamond-fields of Central India :—In the neighbourhood of Panna the principal diamond-bearing stratum is a thin layer of conglomerate, locally known as 'mudda,' lying between the Upper Kaimur sandstone and the Panna shales. The conglomerate is seldom thicker than two feet and does not form a continuous bed. Further east, in the neighbourhood of Itwa, the diamondiferous conglomerate does not rest directly on the Kaimur sandstone, but is separated from it by a 20-25-foot bed of shales and limestone. Another diamondiferous conglomerate occurs above the Rewa sandstones and under the Bhander series. This conglomerate differs from that below the Rewa series in the abundance of pebbles of vein quartz, instead of the different varieties of jasper found so commonly in the man diamondiferous conglomerate near Panna.

The diamonds in these conglomerates, like the associated large pebbles of lighter rocks, are derived from older rocks, and the original home of the gem is still unknown, though a precise recognition of the associated pebbles will gradually indicate the direction in which the mother-rock once occurred and possibly still exists. The

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 261-314, (1906).

most characteristic pebbles in the diamondiferous conglomerates are the jasper-pebbles derived from the Bijawar formation and the vein quartz similar to that traversing the Bundelkhand granites, the latter being especially abundant in the conglomerate lying above the Rewa sandstone.

Besides the diamonds lying still embedded in the conglomerates others are found in the neighbouring detritus derived from the disintegration of the Vindhyan beds. The workings are developed accordingly—some with a view to the removal of the undisturbed conglomerate, and others with the intention of recovering the diamonds included in the more recently distributed detritus.

The undisturbed conglomerate is often covered by considerable thicknesses of younger Vindhyan rocks, and is reached by workings which are often, but not always, deep. These may be called 'direct workings.' In other places the overlying younger rocks have been removed by weather agents, and the conglomerate thus exposed at the surface is available for 'shallow workings.' In the detritus removed from the original conglomerate and deposited in river-valleys the diamonds may be reached by superficial, shallow, or comparatively deep workings, and they may be all spoken of conveniently as 'alluvial workings.'

Production.

The only figures returned for diamonds relate to the production in the Central Indian States of Panna, Charkhari, and Ajaigarh. The production during the five years under review is shown in table 35, the average being 306·71 carats worth £2,799.

TABLE 35.—*Production of Diamonds in Central India during the years 1904 to 1908.*

YEAR.	Quantity.	Value.
	Carats.	£
1904	286·48	*2,636*
1905	172·41	*2,474*
1906	305·91	*5,160*
1907	628·00	*2,784*
1908	140·75	*940*
Average	*306·71*	*2,799*

The average daily attendance of workers on the diamond-fields is returned as follows :—

1904	1,932 persons.
1905	1,890 „
1906	2,051 „
1907	1,084 „
1908	865 „

It is reported that a certain number of diamonds are picked up in the neighbourhood of Wajra Karur in the Anantapur district of the Madras Presidency, but no figures are available as to actual production.

Gold.[1]

Comparison with other countries.

The average annual production of gold in the world during the five years 1904 to 1908 is valued at about 82 millions sterling. Thus India, with an average annual production of £2,266,307 (from table 38) during the same period, contributed only 2·8 per cent. of the total. During the four years 1904 to 1907 India occupied the seventh position amongst the leading gold-producing countries of the world, but in 1908 it fell to the eighth position, as is shown by table 36.[2]

TABLE 36.—*Values of the Gold produced by the Chief Gold-producing Countries during 1908.*

COUNTRIES.	Values.
	£
Transvaal	29,986,469
United States	19,500,000
Australia	12,342,440
Russia	4,500,000
Mexico	3,250,000
Canada	2,750,000
Rhodesia	2,526,007
India (*a*)	2,177,847
New Zealand	2,025,908
West Africa	1,186,342
Other Countries	7,750,000
TOTAL	**87,995,013**

(*a*) Taken from table 38.

1 A general account of the gold occurrences of India and Burma is given in Dr. Maclaren's "Gold," pp. 238-270, (1908). Considerable use has been made of this in preparing this article.

2 *Min. Journ.*, Feb. 20th, 1909, p. 261.

The following table by Mr. H. E. Ede[1] shows the position of India amongst the principal gold-producing colonies and dependencies of the British Empire :—

TABLE 37.—*Relative Contributions of the Principal Gold-producing Colonies and Dependencies of the British Empire.*

—	1904.	1905.	1906.	1907.	1908.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Transvaal . .	38·4	44·7	49·6	54·3	56·5
Australasia .	38·1	33·3	29·5	26·8	23·3
Canada . .	8·1	6·4	4·0	3·4	5·2
India . .	5·7	5·2	4·2	4·2	4·2
New Zealand .	4·8	4·5	4·6	4·0	3·8

Provincial production.

Table 38 shows the provincial production for India during the five years under review. In 1904 no less than 98·2 per cent. (by value) of the Indian output was returned by Mysore, and 1·7 per cent. by the Nizam's Dominions, leaving only 0·1 per cent. as the produce of districts directly under British administration. By 1908, owing to the development of reef mining in Dharwar and of dredging in Myitkyina, the proportion derived from districts directly under British administration had risen to 2·7 per cent.; and, of the remainder, 94·4 per cent. came from Mysore and 2·9 per cent. from the Nizam's Dominions.

Vein Gold: development of the Kolar Field.

The produce of the Mysore State is solely derived from the Kolar district, and from a single vein or reef in that district—a reef averaging only some four feet in thickness, and payably auriferous for a distance of little more than four miles. As has been the case with all other known auriferous deposits in Peninsular India,

[1] *Min. Journ.*, March 6th, 1909, p. 309.

TABLE 38.—*Quantity and Value of the Gold produced in India during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Ounces.	£	Ounces.	£	Ounces.	£	Ounces.	£	Ounces.	£
Bombay—Dharwar	..	..	93	*321*	60	*232*	4.916	*18.641*	7.242	*27.158*
Burma—Myitkyina	216	*810*	620	*2,412*	2.300	*8.850*	3,837	*14.919*	7,950	*30.600*
Other districts (*a*) (Upper Chindwin, Katha, etc).	150	*600*	150	*600*	150	*600*	150	*600*	150	*600*
Central Provinces (*a*).	150	*600*	150	*600*	150	*600*	150	*600*	150	*600*
Hyderabad	10.559	*40,624*	13.167	*50.060*	13.782	*52.801*	13.383	*50,216*	16.437	*62,550*
Mysore	607.578	*2,323.194*	616.758	*2.373,457*	565,208	*2.167.636*	535.085	*2.041.130*	535,653	*2,055,567*
Punjab	370	*1.379*	176	*703*	190	*746*	163	*639*	195	*759*
United Provinces	23	*83*	2	*11*	4	*14*	2	*11*	3	*13*
TOTAL	**619,046**	*2.367.290*	**631,116**	*2,428,154*	**581,844**	*2,231.479*	**557,686**	*2.126.756*	**567,780**	*2,177,847*

(*a*) Rough average estimates.

the attention of Europeans was directed to this vein by the numerous old native workings along its strike. During the Wynaad gold 'boom' of 1878-1882, several companies with huge capitals were floated to work portions of a concession over the Kolar field. Of the capital subscribed the greater portion was devoted to purchase money, and comparatively little was left for working capital. The features of the auriferous deposits were not at first grasped, and much money was wasted in mining in barren ground and amidst ancient workings, which were eventually found to reach to a depth of 300 feet. All the companies floated with such extravagant hopes in 1881-82 were moribund in 1885, and it was only a dying effort of the Mysore Company in that year that disclosed the great richness of the reef and incidentally the disposition of the auriferous chutes.

By 1887 the adjacent companies had resumed operations, and from that time up till 1905 the history of the field has been one of uninterrupted progress and success. During the last three years, 1906 to 1908, there has been a slight decrease in the output from this field, due to zones of lower grade ore being reached in some of the mines. At Ooregum, however, now that greater depths have been reached, the grade of ore is improving, and it is hoped that the other mines, Champion Reef and Balaghat, will show a similar improvement when greater depths are reached. The deepest mines are Mysore and Ooregum, which have each reached a depth of considerably over 3,000 feet measured vertically.

Neither mining nor milling offers any serious obstacles on this field. With the former the necessity for heavy timbering and filling to keep the roadways open is perhaps the most serious. But of late years considerable trouble and uneasiness has been caused by air blasts and quakes, especially in the Champion Reef and Ooregum mines.[1] The ore is not refractory, and yields its gold to a simple combination of amalgamation and cyaniding.

During the five years under review the annual tonnage crushed reached a maximum of 781,281 tons in 1905, and since then has declined slowly to 720,808 tons in 1908. (These figures, returned by the Chief Inspector of Mines for Mysore, are in short tons.)

In 1905 the gold yield reached a maximum of £2,373,457, the largest ever recorded in the history of the field. Since then

[1] W. F. Smeeth, 'Air Blasts and Quakes on the Kolar Gold Field.' *Bull.* No. 2, *Mysore Geol. Dept.*, (1904).

there has been a small contraction in the output, the value of the 1908 output being £2,055,567. For the five years under review the value of gold extracted was £10,969,811, or 37 per cent. of the total value (£29,657,692) extracted in the twenty-seven years since the commencement of work under European supervision. This compares favourably with the value of £9,729,211 of the gold produced during the previous five years. In 1905 the dividends paid reached their maximum value (£1,066,615) for the whole period of the industry; since then there has been a marked annual decline (to £582,488 in 1908), due chiefly to the falling off of the values of the ore won at the Champion Reef and Balaghat mines. The total dividends paid during the five years were £4,217,836 as compared with £4,249,679 paid during the previous five years. This is 33·7 per cent. of the total dividends (£12,505,384) paid since the commencement of the industry.

The above dividends have been paid wholly by five companies situated on the line of the Champion Reef—the Mysore, Champion Reef, Ooregum, Nundydroog, and Balaghat—except for a small dividend paid in 1905 by the Mysore West and Mysore Wynaad Gold Mining Companies, working jointly the Tank Block Mine. A considerable amount of exploratory and mining work has been done by other companies on the Kolar field and elsewhere in Mysore, but hitherto without profitable result, although in several cases ore has been milled and gold won. The companies that have produced gold during the quinquennium, but have not paid dividends, are the Oriental, Coromandel, Gold Fields of Mysore and General Exploration, and the Nanjangud Gold Field Company.

An important improvement scheme, making for the reduction of working expenses, and consequently for the prolongation of the life of the Kolar field, is the introduction of electric power from the Cauvery falls. This work was completed about the middle of 1902, and was designed for the conveyance of 4,000 H.P. over a double line 92 miles long. Since then, the generating plant has been increased so as to supply 6,600 H.P. to the gold field. This supply is continuous, except in years of drought, when there may be short stoppages during the hot weather owing to a scarcity of water in the river Cauvery. The cost per E.H.P. per annum to the mines during the first year was fixed at £29, in order to reimburse the Mysore Government for their capital outlay; but this charge was subsequently reduced to £18 and later to £10 for the

first installation. A third installation to supply 2,000 H.P. is now in hand. The rate will be £10 from the commencement.

In order to supply power for electric lighting and the driving of motors used intermittently, a company, called the Kolar Mines Power Station, Ltd., was formed in 1903, the electricity to be generated by steam power. The company began to supply power at the end of 1904.

The completion of the scheme of water-supply from the Bethamangala Tank, some 6 miles from the field, undertaken by the Mysore Government, now ensures the mines a supply of filtered water sufficient for all purposes.

Table 39 shows the various statistics of production for the Kolar field both for the period under review and for the previous quinquennium.

TABLE 39.—*Statistics of Production in the Kolar Gold-field.*

—	Tonnage crushed.	Value of gold extracted.	Dividends paid.	Royalty paid.
	Short tons.	£	£	£
1899	339,526	1,678,464	762,600	83,154
1900	401,687	1,879,085	767,586	93,619
1901	450,272	1,923,081	874,158	95,219
1902	560,792	1,964,509	825,988	97,365
1903	685,848	2,284,072	1,019,347	113,139
TOTALS for 1899-1903	**2,438,125**	**9,729,211**	**4,249,679**	**482,496**
1904	730,841	2,323,194	1,041,939	115,081
1905	781,281	2,373,457	1,066,615	117,081
1906 (a)	744,165	2,170,470	866,779	107,427
1907 (a)	733,809	2,051,773	660,015	101,157
1908	720,808	2,050,917	582,488	101,861
TOTALS for 1904-1908	**3,710,904**	**10,969,811**	**4,217,836**	**542,607**

(a) This includes 711 tons of ore crushed on the Nanjangud field in 1906 with production of 95 ozs. bar gold, and 464 tons in 1907 with production of gold worth £530.

Total value of gold produced from 1882 to 1908 inclusive	£29,657,692
,, ,, ,, dividends paid .. ,, ,, ,, .	£12,505,384
Royalty paid to Mysore Government from 1882 to 1908 inclusive.	£1,468,881

The work of the field is carried on by Europeans, Eurasians, and Natives, in the following proportions, calculated from the number employed during the year 1907, the latest for which figures are available :—

Europeans (including Italian miners)	1·70
Eurasians	1·22
Natives : men	91·31
Natives : women (employed only on the surface) . .	5·02
Natives : children (under 14 years : employed only on the surface).	0·75

The following table indicates the risks attendant on mining in the Mysore State :—

TABLE 40.—*Showing Fatal Accidents in Mysore Mines for the years 1904 to 1908.*

YEAR.	Number of persons employed.	*Death-rate per 1,000 employed.*	Death rate per £100,000 worth of gold obtained.
1904	29,494	*1·53*	1·94
1905	30,328	*2·51*	3·23
1906	30,446	*2·30*	3·23
1907	30,749	*1·92*	2·89
1908	29,259	*3·07*	4·37
Average .	*30,055*	*2·26*	*3·10*

During the quinquennium prospecting operations for gold have been prosecuted in the Chitaldrug, Mysore, Shimoga, and Tumkur districts of Mysore. The only company outside Kolar that has produced any gold is the Nanjangud Gold Field, Ltd., which produced 95 ozs. of bar gold in 1906 and bullion to the value of £530 in 1907.

Hyderabad (Nizam's Dominions).

The only gold-field in India besides Kolar from which there has been a continuous production of vein gold during the quinquennium is the Hutti field, situated on the Maski band of Dharwar schists in the Lingsagar district of the Nizam's Dominions (Hyderabad). The only company operating on this field is the Hutti (Nizam's) Gold Mines, Ltd. It is an offshoot of the Hyderabad (Deccan) Company,

and was floated in 1901. Crushing with 10 head of stamps was commenced in 1903, with a production of 3,809 ozs. of gold in that year. Since then the number of stamps has been increased to 30. One of the shafts had reached a depth of 1,500 feet by the end of 1908. Dividends have been paid regularly since 1904, the total distribution being 75 per cent. on a capital of £50,000 to the end of 1908. Table 41 gives the production statistics of this mine; it will be seen that the average amount of gold extracted has been 10·7 dwts. worth £2·035 per ton of quartz crushed.

TABLE 41.—*Statistics of Production at the Hutti Mine.*

YEAR.	Tonnage crushed.	*Bar gold produced.*	Value of gold extracted.
	Tons.	*Ozs.*	£
1903	5.735	*3.809*	14.505
1904	17.205	*10,559*	40,624
1905	24.325	*13.167*	50,060
1906	25.350	*13,782*	52,801
1907	27 050	*13.383*	50.216
1908	29,850	*14.305*	54,231
TOTAL	**129,515**	*69.005*	**262,437**

In 1905 another company, known as the Topuldodi (Nizam's) Gold Mines, Ltd., with a capital of £90,000 was formed to take over from the Hutti Company an option held on the Topuldodi block in the Raichur district of the Nizam's Dominions. During 1908, 2,132 ozs. of gold, worth £8,319, were produced. But as the ore developed in the mine proved to be of very low grade, the mine was closed down, and its assets transferred to the Hutti Company.

The Dharwar Gold-field.

The third Indian field on which work has been actively prosecuted during the quinquennium is the Dharwar field, situated on the Gadag band of Dharwar schists, partly in the Dharwar district and partly in the Sangli State, each of which lies in the Bombay

Presidency. There are at present two series of reefs being developed in this field. They are each situated on the western side of the Kappat Gudda range, and in each case the gold occurs in white quartz. The eastern series has been traced by means of old workings for a total distance of 8 miles, in a N. N. W.—S. S.E. direction. The veins, which are lenticular, are arranged *en échelon* in association with a carbonaceous member of a series of argillites, parallel to the schistosity planes. The only producing mine on the field is that near Kabulavatkatti village, originally prospected by the Dharwar Gold Mines, Ltd., during 1902-1904, and now worked by the Dharwar Reefs Gold Mining Company, Ltd. Crushing was commenced in 1907 with the production during the year of 4,916 crude ounces, worth £18,641, increasing to 7,242 ounces, worth £27,158, in 1908. The other companies working on this line of reefs are the Dharwar Gold Mines (the company first formed), Sangli Gold Mines, the Gold Fields of Dharwar, the Gold Fields of Mysore and General Exploration Company, and the Mysore Gold Mining Company, the two latter working on option blocks.

The other series of reefs, known as the Hosur series, lies some four miles to the west. The reefs lie in chlorite-schist and massive gritty schist near felsite. The companies holding concessions on this series are the Dharwar Gold Mines, the Hosur Gold Mines (formerly the Hosur Gold Mines of Dharwar), the Champion Reef Gold Mining Company of India, the Road Block Gold Mines of India, and the Mysore Reefs (1905) and Explorers, the three companies last named holding options only. The mine nearest the producing stage seems to be Hosur.

Anantapur.

In 1902 Mr. E. W. Wetherell, of the Mysore Geological Department, discovered a previously unknown belt of Dharwar schists stretching in a north and south direction for some 32 miles through the Anantapur district of Madras, but just touching the north-east corner of the Pavagada taluk of the Tumkur district of Mysore. Several large quartz reefs occur in this belt, and near the village of Ramgiri old gold workings were found. The gold occurs in quartz veins principally in chloritic and argillaceous schists. A company, called the Anantapur Gold Field, Ltd., was formed in 1905. In 1908 it transferred a portion of its holdings (the Buruju block) to a new company, the North Anantapur Gold Mines, Ltd., and another portion (South Jibutil block) under option to the Nundydroog

Company of Mysore. Although some encouraging results have been obtained, none of the mines have yet reached any considerable depth or passed the prospecting stage.[1] The mines are situated about 9 miles westward from Nagasamudram station on the Madras and Southern Mahratta Railway.

The Nilgiris.

The Nilgiris, after many vicissitudes, has ceased to be a mining area; but some native workers are reported to be making a living by roughly treating the waste heaps, from which they extract a small quantity of gold.

Gold in sulphide lodes.

Besides occurring in the free state in quartz veins, as in all the areas noticed above, gold is sometimes found in sulphide lodes enclosed in the sulphide minerals. Thus gold occurs in Sikkim among the mixed sulphide lodes (chalcopyrite, pyrite, pyrrhotite, blende, etc.), and in the copper-bearing lodes of Sleemanabad in the Jubbulpore district of the Central Provinces. Assays in the latter case have occasionally shown amounts as high as 15 dwts. per ton.

Alluvial gold.

Alluvial gold-washing is carried on in many places in British India, but from the fact that the washers invariably combine this pursuit with other occupations, and because the individual return is exceedingly small and is locally absorbed for jewellery, complete returns are not available.

These, so far as they go, give little hope of the discovery of rich alluvial deposits in Peninsular India, or indeed in any part of India affected by the monsoon rains and dependent on them alone for the supply of the rivers. For concentration of gold a comparatively equable current is essential—a condition rarely obtainable in the gravel river beds of India, where alone gold would be found, for these are almost dry in the cold weather and roaring torrents in the rains. The greater possibilities of dredging on the Irrawaddy appear to arise from the fact that the waters of that river are derived from ranges where, even in the cold weather, there is a heavy rainfall.

[1] See also a note on the field in the *Mining Magazine*, II, p. 42, Jan. 1910.

Assam.

In Upper Assam[1] tributaries, such as the Subansiri, that flow from the north into the Brahmaputra carry small quantities of gold. One small bar near the mouth of the Subansiri gorge was found to contain more than a dwt. per cubic yard; but the quantity of gravel available was very small. It is probable that some of the gold of this region is derived, immediately, from the Tipam (Siwalik) sandstones, and that the source of the gold in the Lohit branch of the Brahmaputra is to be sought in the metamorphic rocks of the Miju ranges.

Chota Nagpur, Bengal.

In the Chota Nagpur division of Bengal, alluvial gold is found widely distributed, but the gold washing is of most importance in the Singhbhum and Manbhum districts, and is chiefly confined to the valley of the Subarnarekha ('golden-streaked') river and its tributaries. The number of persons engaged in the industry fluctuates considerably, the figures for 1904 and 1908 being shown below :—

	1904.	1908.
Manbhum .	255	517
Ranchi .	168	200
Singhbhum .	413	71

The average earnings amount to only As. 1-6 to 2 a day.

The result of Dr. Maclaren's[2] work was to show that nowhere in Chota Nagpur had gold deposits—either alluvial or vein—been found worth working on European lines.

Burma: native gold-washing.

The native gold-washing industry is carried on from year to year in several districts in Burma, usually by only a few people in each district; the number so engaged varies from year to year partly in accordance with the character of the seasons. No accurate figures of production are available. In 1908 gold was washed in the following districts :—Bhamo, Katha, Lower Chindwin, Myitkyina,

[1] Maclaren, *Rec. Geol. Surv. Ind.*, XXXI. pp. 179-232, (1904).
[2] *Rec. Geol. Surv. Ind.*, XXXI, pp. 59-91, (1904).

Pakokku, Prome, Shwebo, Toungoo, and Upper Chindwin. Actual figures returned are :—

	Ozs.
Katha	1
Pakokku	79
Upper Chindwin	62
	142

Judging from reports relating to other districts, the total amount of alluvial gold obtained by the native washers must be much in excess of this figure. Hence 150 ozs. annually is inserted in table 38 as a figure that is probably well within the mark.

Burma: gold-dredging; the Irrawaddy.

The gold-dredging on the upper reaches of the Irrawaddy is largely due to the enterprise of Mr. W. R. Moore who (in association with Captain J. Terndrup) was granted in 1901 a five-years' license for dredging within the bed of the river for a stretch of some 120 miles from the confluence above Myitkyina to the mouth of the Taiping above Bhamo. In 1904 the license was extended for a period of thirty years and restricted to about 88 miles of the river from Sinbo to the confluence, while sanction was given at the same time to transfer the concession to the Burma Gold Dredging Company, which was registered at Rangoon in 1903. In 1907 permission was given to alter the limits of the concession by exchanging 15 miles of the lower end for 10 miles along the 'N Maikha and 5 miles along the Mali-kha. Application has now been made for a further exchange of the Irrawaddy part of the concession for 15 miles along the eastern river, 'N Maikha.

The gold-bearing alluvium is coarse gravel with the gold disseminated fairly uniformly. The average value of the gravel seems to be about 3 grains (6 annas) per cubic yard. Small quantities of platinum and platinoid metals are recovered with the gold. The annual production of gold (see table 38) has risen from 370 ozs. in 1903 to 7,950 in 1908, of a total value of £58,992. The first dividend (2½ per cent.) was declared in 1908.

The Chindwin.

The alluvial stretches of the Chindwin river have been found to contain gold at many points, but systematic prospecting has in most cases shown them to be valueless as dredging propositions, although

they are a source of income to the native gold washers. A concession for 180 miles of the Lower Chindwin river, stretching from Minsin to Homalin, was granted about 1903 to the Burma Mines Development and Agency, Ltd., and in 1905 transferred to the Mandalay Gold Dredging Company, Ltd. A dredger was obtained, but became stranded while being towed up the Chindwin river, and no further work was attempted.

The Uyu, a tributary of the Upper Chindwin, has also been prospected for alluvial gold, but with little success so far.

The Namma.

In 1905 the Namma Gold Dredging Company, Ltd., with a capital of £70,000 (£55,000 issued, of which £30,000 went to vendors) was floated in London to work two stretches of the Namma river, a tributary of the Salwin, in the Shan States. A careful preliminary investigation had indicated the existence of approximately 40,000,000 cubic yards of gravel averaging 5·43 grains of fine gold per cubic yard. A steam dredger was purchased and floated in a paddock on the Upper Namma, and it was then found that the deposit was unfitted for this mode of exploitation. It consists of gravel and boulders embedded in a stiff clay, hardened by calcareous tufa derived from the limestone forming the sides of the valley, and is therefore not sufficiently loose to enable the buckets of the dredger to excavate it. The venture, therefore, ended in failure.

The alluvial gold deposits of Loi Twang in the Shan States, worked by native washers, have been examined in detail by Mr. T. D. LaTouche and found to be of no commercial value.[1]

Other Burmese rivers to which attention has been directed by European prospectors, without any tangible results so far, are the Mole Chaung, Taiping, and Shweli, tributaries of the Irrawaddy; the Upper Chindwin; the Salwin; and the streams of Tavoy, where gold has been found associated with tinstone.

The Central Provinces.

Alluvial gold occurs in the sands and gravels of many of the rivers and streams of the Central Provinces, particularly in those that drain down from or run over areas where the ancient crystalline and metamorphic rocks crop out. According to an "Industrial Monograph on Gold and Silverware of the Central Provinces," by H. Nunn, I.C.S., published at Allahabad in 1904, which contains also the best account yet published of the native gold-washing

[1] *Rec. Geol. Surv. Ind.*, XXXV, pp. 102—113, (1907).

industry of this province, gold-washing has been carried on at various times in the following districts :—Balaghat, Bhandara, Bilaspur, Chanda, Jubbulpore, Mandla, Nagpur, Raipur, Sambalpur, and Seoni. During 1908, however, washing for gold is reported from five districts only—those shown in table 41. From the report quoted it appears that in addition to the washers of auriferous sands there are people engaged in a cognate industry, consisting of the extraction of the gold and silver particles, called in England "lemel," from the dust of a Sunar's shop and furnace by a two-fold process, first of actual winnowing, and then of washing in a river. The resultant is treated by refining processes. The persons practising this "lemel" washing, which is recorded for the Balaghat, Bilaspur, and Hoshangabad districts, are Mahomedans, and it is desirable to distinguish their occupation from that of the gold washers proper, although there is doubtless at times a certain overlapping of the two occupations. The gold washers are variously known in different parts of the province as *jharas*, *jharias*, *sonjharas*, *sonjhirias*, and *sonzaras*. The report cited gives a full account of the methods of washing and treating the gold as practised in the Tirora tahsil of the Bhandara district. Table 41 summarises such information as is available with regard to the year 1908, and from this it seems probable that there is an annual production of not less than 150 oz. of gold in the Central Provinces, and such has been entered up in the production table 38 given on page 85.

TABLE 41.—*Statistics of Output and Labour for 1908 in the Native Gold Washing Industry of the Central Provinces.*

DISTRICT.	No. of persons engaged in gold washing.	Year's production.	Daily earnings per worker.
		Oz.	Annas.
Balaghat	35	30	3 to 4
Bhandara	40 to 50 in each band.	9 to 15 per year per band.	3 to 4 per family.
Bilaspur	20	28	5
Chanda	30	(a)	6 to 8
Nagpur	25 to 40	(a)	4 to 6

(a) No figures available.

Kashmir.

Washing for alluvial gold has been practised along the valley of the Indus in the Baltistan and Ladakh divisions of Jammu and Kashmir State. In 1903, 106 oz. of gold were obtained from Ladakh. In Kargil and Skardo, Baltistan, the washing of ancient gravel deposits has been carried out on quite an extensive scale, actual mining operations having been undertaken to excavate the gold-bearing bands in the old river terraces in the Dras valley. The production of gold from Kashmir in 1904 was returned as 24 oz. and in 1905 as 10 oz., and 4·8 oz. in 1906, and *nil* for the two succeeding years. A small quantity of alluvial gold is said to have been obtained by Tibetans from sub-recent gravels on the Para river on the border between Rupshu and the Tibetan Province of To-tzo.[1]

Punjab.

Gold-washing flourishes, also, in some of the Punjab rivers, especially the Indus, and the production for the quinquennium totals 1,094 oz., giving an average annual figure of 218 oz. In 1908 a prospecting license for dredging over a length of 48 miles of the Indus, in the Attock district of the Punjab and the Peshawar and Hazara districts of the North-West Frontier Province, was granted to Lieutenant M. Snee, who has, it is understood, given an option over his concession to the Kashmir Mineral Company, Ltd.

United Provinces.

In the United Provinces the industry was reported in 1904 as employing about 100 workers in the Nagina tahsil of Bijnor district, and smaller numbers in Garhwal and Naini Tal. The total reported production during the quinquennium is 34 oz.

Graphite.

Mode of occurrence.

Graphite occurs in small quantities in various parts of India—in the so-called khondalite series of rocks in the Vizagapatam hill-tracts and adjoining Chhattisgarh Feudatory States, in a corresponding series of rocks in Coorg, in the Godavari district of the Madras Presidency, and in the Ruby Mines district in Upper Burma; and in Travancore. It has also been discovered recently in Sikkim, where a graphite vein, averaging about 13 inches in thickness, has been found

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).

during the prospecting operations conducted by Messrs. Burn & Co. at about half a mile to the north of the road from Tsuntang and Lachen. The quality of the mineral appears to be good, large bulk samples having given a return of 93 per cent. of graphite. Other veins of graphite are known to occur in the area, but have not yet been examined in detail.[1]

The graphite deposits of Travancore occur under conditions similar to those of Ceylon, which is but a continuation of the charnockite series and associated rocks of South India. The Ceylon graphite has been made the subject of an elaborate study by E. Weinschenk, who regards it as of igneous origin,[2] a conclusion in agreement with its occurrence in South India.[3] Small quantities of graphite have been extracted in Godavari and Vizagapatam, but practically the whole of the Indian output comes from Travancore, where 13,414 tons of graphite, worth, on the average. £4·74, have been mined during the period covered by this Review; for the detailed figures of production see table 42. Of the world's total production of graphite ranging between 70,000 and 100,000 tons annually, about one-third is obtained from Ceylon.

Production.

TABLE 42.—*Production of Graphite during the years 1904 to 1908.*

—	1904.		1905.		1906.		1907		1908.	
	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Travancore	3,256	*16,627*	2,260	*15,182*	2,596	*9,998*	2,429	*7,387*	2,873	*14,365*
Godavari .	67	(*a*) *402*	64	(*a*) *384*	..	..	4	(*a*) *24*	...	..
Vizagapatam	..	..	..	..	4	(*a*) *24*	..	..	..	..
TOTAL .	**3,323**	*17,029*	**2,324**	*15,566*	**2,600**	*10,022*	**2,433**	*7,411*	**2,873**	*14,365*

(*a*) Estimated.

[1] According to a report by C. Wilkinson; for permission to make use of this we are indebted to Mr. A. Whyte of Raniganj.

[2] Die Graphitlagerstätten der Insel Ceylon. Abhand., d. k. Bayer., Akad., 1901, xxi, 279-335.

[3] Holland The Charnockite series, *Mem. Geol. Surv. Ind.*, XXVIII, 1900, 126; and the Sivamalai series, *Mem. Geol. Surv. Ind.*, XXX, 1901, 174.

Iron.

Production.

Bengal is the only province in India in which iron-ore is mined for smelting by European methods. Table 44 shows the annual production in this province during the five years under review. On comparing this with table 28 of the previous Review (page 52) it will be seen that the maximum output was reached in 1905 (98,398 tons). Since then there has been a decline to about 67.000 tons in 1907 and 1908, with a corresponding decrease in the amount of pig-iron produced at the Barakar Iron-works (see page 102). The average value of the ore produced in Bengal during the five years is 3·26 shillings per ton. The annual production from other provinces has averaged 4,755 tons. For the total production for each year see table 43.

General character of the iron-smelting industry.

Iron smelting was at one time a widespread industry in India, and there is hardly a district away from the great alluvial tracts of the Indus, Ganges, and Brahmaputra, in which slag-heaps are not found. But the primitive iron-smelter finds no difficulty in obtaining sufficient supplies of ore from deposits that no European iron-master would regard as worth his serious consideration. Sometimes he will break up small friable bits of quartz-iron-ore schist, concentrating the ore by winnowing the crushed materials in the wind or by washing in a stream. Sometimes he is content with ferruginous laterites, or even with the small granules formed by the cementation of the rusty cement in ancient sandstones. In ancient times the people of India seem to have acquired a fame for metallurgical skill, and the reputation of the famous *wootz* steel, which was certainly made in India long before the Christian era, has probably contributed to the general impression that the country is rich in iron-ore of a high-class type. It is true that throughout the Peninsula, which is so largely occupied by ancient crystalline rocks, quartz-hematite and quartz-magnetite schists are very common in the Dharwarian system, the system of rocks that lithologically, as well as in stratigraphical relationship, corresponds approximately to the Lower Huronian of America. But most of these occurrences consist of quartz and iron-ore so intimately blended that only a highly siliceous ore of a low grade can be obtained without artificial concentration. These occurrences of quartz-iron-ore schist are so common in India that newly recorded

TABLE 43.—*Quantity and Value of Iron-ore raised during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	
Bengal .	65,115	9,303	98,398	*13,942*	86,329	*13,357*	66,414	*12,040*	67,175	*13,782*
Other Provinces and States .	6 570	*1,752*	4,933	*1,315*	5,140	*1,371*	2 315	*617*	5 125	*1,367*
Total, STATUTE TONS AND £ .	**71,685**	*11,055*	**103,331**	*15,257*	**91,469**	*14,728*	**68,729**	*12,657*	**72,300**	*15,149*
Total, Metric Tons . .	72,832	..	104,984	..	92.933	..	69,829	..	73,457	..

TABLE 44.—*Iron-ore raised in Bengal during the years 1904 to 1908*

YEAR.	Burdwan.	Singhbhum.	Manbhum.	Sambalpur.	Hazaribagh.	TOTALS FOR BENGAL.		
						Quantity.	*Value.*	Value per ton.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	£	
1904	60,085	5,030	..	..	..	65,115	9,303	2·86
1905	86,029	2,381	9,288	700	..	98,398	13,942	2·83
1906	60,991	7,563	16,932	827	16	86,329	13,357	3·09
1907	44,488	11,036	10.179	706	5	66,414	12,040	3·63
1908	34,754	18,907	12,709	802	3	67,175	13,782	4·10
Average	*57,270*	*8,983*	*9,821*	*607*	*5*	*76,686*	*12,485*	*3·26*

NOTE.—Ore raised in Burdwan, Singhbhum and Manbhum is for the Barakar Ironworks. That raised in Sambalpur and Hazaribagh is smelted in native furnaces.

instances are generally passed over as matters of very little immediate economic interest. During the past four years, however, distinct ore-bodies of considerable size and richness have been recognised in the Central Provinces and in the Mourbhanj (Mayurbhanj) State.

Earlier attempts to introduce European processes for the manufacture of pig-iron and steel, in India, have been such conspicuous failures that there is naturally some hesitation in reposing confidence in the project now launched by Messrs. Tata, Sons & Co.

Attempts to introduce European processes.

About the earliest attempt to introduce European processes was due to the enthusiasm of Mr. Josiah Marshall Heath of the Madras Civil Service, who, having resigned the service of the East India Company, obtained the exclusive privilege of manufacturing iron on a large scale in the Madras Presidency. In 1830, trial works were erected at Porto Novo in the South Arcot district, and were maintained by subsequent financial assistance from the East India Company. The business was taken over in 1833 by the Porto Novo Steel and Iron Company, and additional works

were started at Beypur on the Malabar Coast. Various concessions were granted to Mr. Heath and the succeeding Iron Company, but in spite of these, the undertaking proved to be a failure. In 1853, a new Association, known as the East India Iron Company, was started with the capital of £400,000. This Company obtained various concessions from Government, and erected two blast furnaces, one in the South Arcot district and another on the Cauvery river, in the Coimbatore district. These furnaces were stopped in 1858, whilst operations at Porto Novo ceased in 1866, and at Beypur in 1867. Other attempts to introduce European processes have been made in the Birbhum district of Chota Nagpur and at Kaladhungi in Kumaon. But the only scheme which has proved to be a financial success is that now in operation near Barakar in Bengal. Even the Barakar Iron-works passed through various vicissitudes of fortune, and showed no signs of financial success, until they were taken over by the present Managing Agents, Messrs. Martin & Co.

Bengal Iron and Steel Company, Barakar.

Production of pig-iron.

The Barakar Iron-works were taken over by the present Company in 1889 and completely re-modelled. There are now three blast furnaces in operation with an annual productive capacity of 75,000 tons of pig-iron, but the output is restricted to very much less on account of the limited demand for pig-iron. During the past five years the production of pig has been as follows:—

	Tons.
1904	40,937
1905	44,764
1906	46,890
1907	39,312
1908	37,692

The following are average analyses of the pig-iron produced:—

——	Grades 1, 2, 3.	Foundry pig, 3 and 4.
	Per cent.	Per cent.
Graphitic carbon	3·13	2·98
Combined ,,	0·23	0·32
Silicon	2·99	2·26
Phosphorus	1·20	1·21
Manganese	1·40	1·13
Sulphur	0·022	0·03

Castings.

The iron foundries now cover an area of 104,000 square feet, and include pipe-foundries, sleeper and chair foundries, as well as arrangements for miscellaneous castings. During the past five years the production of castings has been as follows :—

	Tons.
1904	14,882
1905	18,802
1906	11,764
1907	12,304
1908	11,595

The blowing engines include two Barclay, one Galloway of 750 H. P. and one Parson's turbo of about the same horse-power. The Cowper heating stoves, ten in number, are 21 × 65 feet, and foundations are ready for a fourth blast furnace designed for ferro-manganese manufacture.

Coke.

The coke used hitherto has been made mostly in open kilns, and the ash-percentage, already high in the coal, is correspondingly high in the coke ; consequently, with the large proportion of flux required, the furnaces show a comparatively low productive capacity. It is necessary also to keep the furnaces low on account of the inability of the coke to maintain a heavy burden. The following is the average analysis of the coke now used :—

	Per cent.
Ash	26·69
Moisture	3·88
Carbon	69·43

The Company is now putting up a battery of 36 Simon-Carvès ovens for a production of 40,000 tons of coke per annum. It is not intended at first to add the usual bye-product recovery plant ; this will be, however, put up afterwards.

Coal.

The coal supply is drawn partly from the Company's collieries near the works at Kendwa and Ramnagar and partly from the associated Company

owning collieries at Noonoodih in the Jherria field. The following are average assays of the coal used :—

—	Noonoodih.	Ramnagar.	Kendwa.
	Per cent.	Per cent	Per cent.
Ash	12·00	12·25	15·00
Volatile matter	29·50	29·52	29·15
Sulphur	0·50	0·53	0·55
Fixed carbon (by difference) . . .	58·00	57·70	55·30

Flux.

The limestone used as flux is obtained from the Vindhyan beds at Satna in the Rewa State, and gives the following average analysis :—

	Per cent.
Calcium carbonate .	90·62
Silica . . .	6·25
Ferric oxide and alumina	1·10
Magnesium carbonate	1·86
	99·83

Iron-ore.

The site of the Barakar Iron-works was originally chosen on account of the proximity of both coal and ore supplies. The outcrop of iron-stone shales between the coal-bearing Barakar and Raniganj stages stretches east and west from the works, and for many years the clay ironstone nodules obtainable from this formation formed the only supply of ore used in the blast furnaces.

The ore of this kind now obtained gives the following analysis :—

	Per cent.
Iron .	43·43
Silica .	16·44
Manganese	2·15
Phosphorus	0·86

Recently, magnetite and hematite have been obtained from the Manbhum and Singhbhum districts.

The average analysis of the Manbhum and Singhbhum ore is given as follows :—

	Per cent.
Iron	49·90
Silica	17·54
Manganese	0·24
Phosphorus	0·13

Singhbhum iron-ores.

The deposits at present being worked by the Bengal Iron and Steel Company in Singhbhum are situated a short distance southwards from Kalimati, Bengal-Nagpur Railway. But two deposits, reported to be of very high grade and large size, have been located in the Saranda forests of south-west Singhbhum. They are known as Notu Hill and Buda Hill, and are, respectively, 12 miles east-south-east and 8 miles south-east, as the crow flies, of Manharpur, Bengal-Nagpur Railway. The ore of Notu Hill, consisting of hematite with some limonite, is said to average 60 to 64 per cent. of iron, and that of Buda Hill, judging from surface samples, about 60 per cent. of iron. The advisability of laying down a narrow gauge railway to tap these deposits is under consideration.

The Kalimati ores may be divided into two groups separated by the Dhoba range of hills: those near Turamdih, and those near Hakigora. The Turamdih deposits are situated about 4 miles southwards from the railway and occur in the villages of Kudada, Turamdih, and Talsa, in some foot-hills on the northern base of the Dhoba range. The 'country' is a series of magnesian schists, not yet studied closely in the laboratory, but in part consisting of steatite. The iron-ore is magnetite, and occurs in five ways :—

(1) as scattered granules in the magnesian schists;
(2) as larger patches of irregular shape in the schists;
(3) as definite veins traversing the rocks in any direction;
(4) as veins up to 3 feet thick of magnetite and quartz, with secondary limonite and chert;
(5) as residual accumulations of granules and fragments of magnetite in the overburden resulting from the weathering and breaking down of the magnesian schists.

An attempt is being made to work the magnetite veins found *in situ*, but the chief source of the ore won is the residual accumulations, from which the ore is obtained by sifting and picking.

The Hakigora deposits are situated at a distance of about 8 miles southwards from the railway and occur as a line of small hillocks to the south of the Dhoba range. The ore occurs as the banded hematite- and magnetite-quartzites so typical of the Dharwars. Here also a little ore is won *in situ*, but the chief source of the ore is in the detrital deposits formed by the breaking down of these ferruginous quartzites. The following are the amounts of ore won at these two areas in 1906 and 1907 :—

	1906.	1907.
	Tons.	Tons.
Turamdih area	8.285	9.731
Hakigora area	540	1.375
TOTAL	8,825	11,106

The following table shows the quantity of ore used during the past five years :—

TABLE 45.—*Iron-ore used at the Barakar Iron-works.*

YEAR.	Statute Tons.	*Metric Tons.*
1904	87.923	*89.332*
1905	90.249	*91.697*
1906	89.406	*90.840*
1907	76.907	*78.140*
1908	72.051	*73.207*

Labour.

The average number of persons employed daily at the Barakar Iron-works, exclusive of labour employed by contractors, is as follows :—

YEAR.	Blast furnaces.	Foundries and machine shops.
1904	804	2,249
1905	1,029	1.947
1906	786	1.921
1907	624	1,809
1908	581	2,049

The Tata Iron and Steel Company.

Since the issue of the Review for 1898-1903 an important move towards the utilisation of our resources in iron-ore has occurred through the flotation of the Tata Iron and Steel Company, which was registered on the 26th August 1907, with a nominal capital of Rs. 2,31,75,000 (£1,545,000). The Company holds concessions for iron-ore in the Mourbhanj (Mayurbhanj) State of Orissa, near Dhullee, 38 miles south of Rajnandgaon in the Raipur district of the Central Provinces and smaller deposits in the Drug district. It also possesses a manganese-ore property near Ramrama in the Balaghat district, Central Provinces, as well as deposits of limestone near Katni, dolomite in Chota Nagpur, and coal in the Jherria field.

A site for the works has been secured in the Singhbhum district to the north of Kalimati Railway Station, 153 miles from Calcutta, and at the junction of the Khorkai and Subarnarekha river, from which it is proposed to draw the water required for the works and the new town. The site has already been cleared, arrangements made for the water-supply, for the construction of a cooling tank of 295 acres, and of the branch railway required to connect the works with the main line of the Bengal-Nagpur Railway.

It is proposed to commence with two blast furnaces for an annual production of about 120,000 tons of pig-iron, and steel furnaces for an output of about 70,000 tons, mainly in the first instance of rails and beams.

The Bengal-Nagpur Railway Company, with the sanction of the Government of India, has agreed to construct the line from the works to the ore-fields in Mourbhanj, a distance of under 40 miles, and the Government have agreed to purchase at import prices 20,000 tons of steel rails annually for ten years, on the understanding that the recognised specification is complied with.

The preliminary operations which led to the formation of this Company were inaugurated by the late Mr. J. N. Tata, and were carried on by his successors in the firm of Messrs. Tata, Sons & Co., Ltd., Bombay. According to the prospectus, the vendors receive the expenses of their preliminary operations, amounting to Rs. 5,25,000 (£35,000), plus Rs. 15,00,000 (£100,000) in ordinary shares, the cash paid for expenses being re-invested in shares plus an additional sum of Rs. 4,75,000 (£31,666). Messrs. Tata, Sons & Co. also become the Managing Agents of the new Company for the

first period of eighteen years on consideration of a remuneration of 5 per cent. on the annual net profits, with a minimum remuneration of Rs. 50,000 (£3,333), commencing only from the 1st July 1910.

Iron-ores of Mourbhanj State.

Although the Tata Iron and Steel Company possesses slightly richer and purer ore-bodies in the Raipur district, it is intended in the first instance to work the deposits in Mourbhanj, which are nearer a site that is otherwise suitable on account of the required water-supply, proximity to the subsidiary requirements in coal and limestone, and its situation within striking distance of the largest market for finished products.

The occurrence of valuable iron-ore deposits in Mourbhanj was first noticed by P. N. Bose,[1] who mentioned the following occurrences :—

(*a*) Bamanghati sub-division—
- (1) Gurumaishini Hill, over an area of 8 square miles.
- (2) Near Bandgaon in Saranda-pir.
- (3) Sulaipat-Badampahar range from Kondadera to Jaidhanposi, a distance of some 12 miles.

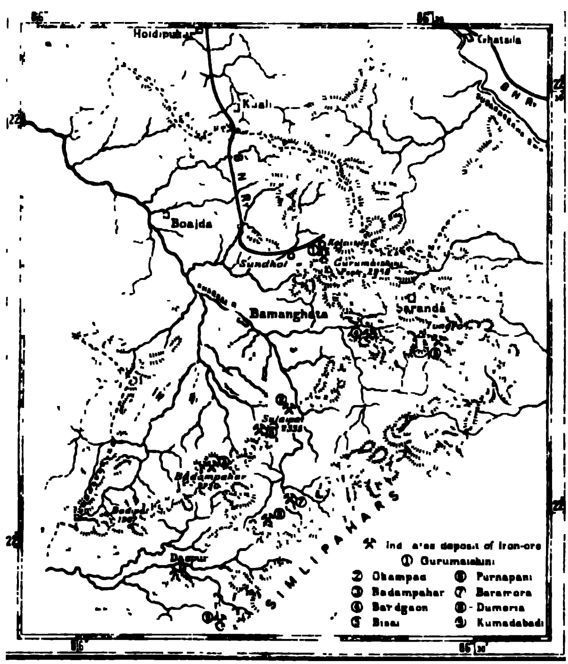
(*b*) Panchpir sub-division—
At several places from Kamdabedi and Kantikna to Thakurmunda, a distance of 25 miles.

(*c*) Mourbhanj proper—
Simlipahar range, and the sub-montane tract to the east (Gurguria, Kendua, and Baldia).

Subsequently, on the possibility of these ores being suitable for the proposed iron and steel works, they were re-examined by Messrs. C. P. Perin and C. M. Weld, who arranged for detailed prospecting operations after securing prospecting rights from His Highness the Maharajah. A subsequent examination of the ground by Mr. W. Selkirk having demonstrated the existence of sufficient ore to warrant operations on a large scale, a lease was granted to the Company over 20 square miles on a royalty-scale that will work out to an average of 2·625*d*. per ton for the first thirty years and 5*d*. per ton for the next following thirty years, on an annual output of 200,000 tons of ore.

[1] *Rec. Geol. Surv. Ind.*, XXXI, p. 168, (1904).

Recent prospecting operations have determined the existence of over a dozen considerable deposits of high-grade ore in the more accessible parts of the State (see fig. 10). Of these deposits three, namely, Gurumaishini, Okampad (Sulaipat), and Badampahar, so far overshadow the others that reference will be made in detail to them alone. The chief point of interest in connection with the smaller deposits is that in every case the nature or type of occurrence is practically identical with the great deposits, they being miniature reproductions as it were of the latter. As the main work of the prospectors has been devoted to the first necessary problem of determining the superficial disposition of the richer ore-bodies, very little has been done so far in the way of studying the geological relations and genesis of the ores.[1]



Scale :—1 inch = 16 miles.

Fig. 10.—Map showing position of the Mourbhanj iron-ore deposits.

The ore-deposits have all been found to take the form of roughly enticular leads or bodies of hematite, with small proportions of

1 We are indebted to Mr. C. M. Weld for the observations summarised below.

magnetite, in close association with granite on the one hand and granulitic rocks on the other. These latter have been noted in the field as charnockites, the term being employed, rather loosely no doubt, but probably in the main correctly, to cover types of pretty widely varying acidity. In still more intimate association with the ores than either of the foregoing were found masses of dense quartz rocks, frequently banded, and banded quartz-iron-ore rocks. These last are of the types so commonly associated with Indian iron-ores, but are here not so prominent as is usually the case. Lastly, there exists a net-work of basic dykes certainly

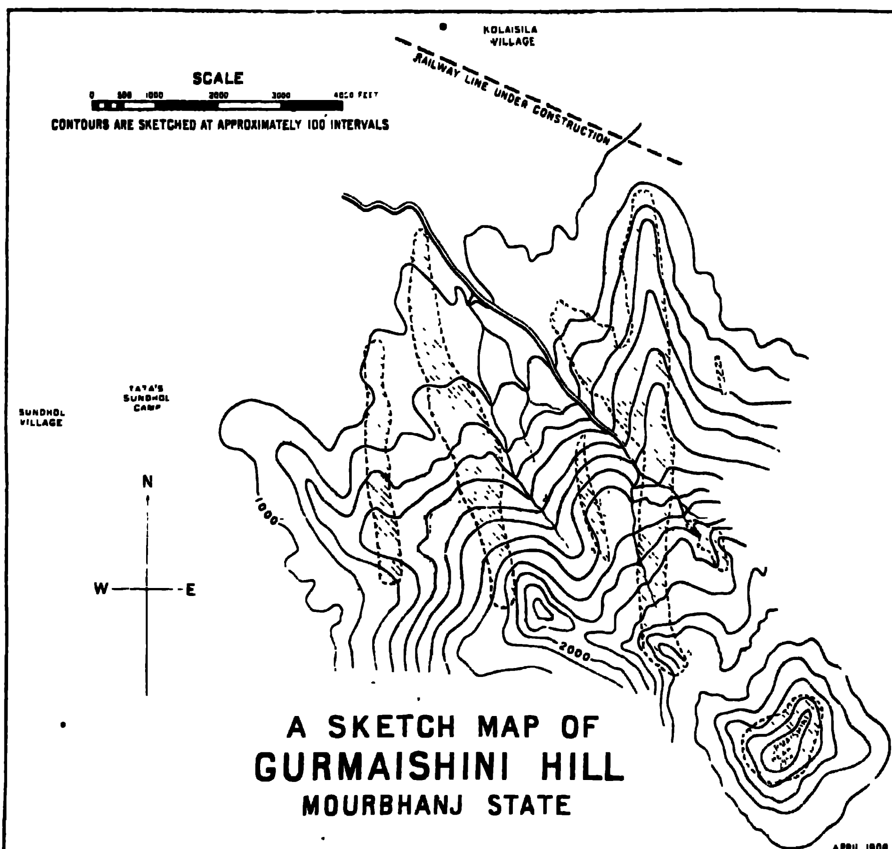


Fig. 11.

cutting the granite and apparently cutting the iron-ores and charnockite.

In a very broad general way the impression so far received has been that the ore-bodies occur at or near the contacts between the granite masses and the charnockites. This impression is pregnant with suggestion, but needs a great deal of verification. The relative age of the granite and charnockite has not as yet been determined.

(1) Gurumaishini.

The Gurumaishini hill-mass, with its three prominent peaks, the highest rising to an elevation of 3,000 feet above the sea-level, and its numerous flanks and spurs, forms a conspicuous feature in the topography of the northern part of the State. The enormous bodies of iron-ore offered at this point and their accessible position have combined to make it the first point of attack. The ore deposits of Gurumaishini occur in three parallel and separate leads (see fig. 11), which are 7,000, 5,500, and 3,000 feet respectively in length, and vary in width from 300 up to 700 or more feet. Further, there are three large, isolated, irregularly-shaped masses, the 3,000-foot peak itself being one of these. The vertical difference in level between the lowest and highest crops of ore is practically 2,000 feet.

The quantity of ore is certainly very great, the superficial area occupied by it amounting roughly to ten million square feet. It is too early to put forward any formal estimate of tonnage, however, as we are able to judge of the depth of the ore only from the vertical differences in elevation of the various outcrops. In addition to this ore in place there are large blankets of rich ore-'float' extending over some 750 to 800 acres.

The quality of the ore is best indicated by quoting the following analyses of samples taken in the course of the several examinations to which the deposits have been subjected :—

	Iron.	Phosphorus.	Sulphur	Silica.
	Per cent.	Per cent.	Per cent.	Per cent.
Average of eleven samples, both solid and 'float' ore	61·85	0·135	0·036	4·08
Average of twenty samples of 'float' ore	61·46	0·048	0·036	3·34
Average of ten samples of solid ore	64·33	0·075	0·021	1·64

A number of these samples was put through a complete analysis, thereby proving the absence of titanium, chromium, zinc, nickel and cobalt (except in one case where 0·090 per cent. was found), copper, lead, and baryta; and the presence of arsenic in traces only (in one case up to 0·008 per cent.).

The Gurumaishini ore will be mined by open cuts, the breasts advancing along the ridges in terraces or benches, with gravity inclines to lower the product to the bottom of the hill, where it will meet the broad gauge railway. A large proportion of the first few years' despatches will be 'float'-ore, gathered up at a very minimum of expense. The day when ore below drainage will have to be drawn upon is very far distant.

(2) Okampad.

The Okampad ore deposit is situated just west of the Khorkai river, where the latter breaks through the Sulaipat-Badampahar range. Okampad is a conspicuous peak, only slightly lower than the Sulaipat peak (2,535 feet elevation) which lies one mile to the south-west of the former. Gurumaishini lies 12 miles to the north-north-east. A representative sample of the ore gave on partial analysis:—Fe, 63·11; P, 0·029; S, *nil*; Ti, *nil*, per cent.

A 13 to 15-mile extension of the Gurumaishini Railway will tap the Okampad deposit when the time comes for its development.

The ore-body occurs as a single great lens, exhibiting at one point a scarp about 300 feet high, and covering a superficial area of some 300,000 or more square feet in plan. There are, besides, two smaller outliers, and about 165 acres of 'rich float'-ore. The immediate associates of the ore are banded quartz-iron-ore rock and a dense blackish quartzite, the latter especially abundant; all these are completely enclosed in what has been referred to in the field notes as trap. The low-lying country to the north-west is occupied by granite.

Four samples of Okampad ore, taken at two different times and by two different observers, gave the following average analysis:—Fe, 67·65; SiO_2, 1·58; P, 0·043; S, 0·012 per cent.

(3) Badampahar.

The last of the three major deposits occupies the Badampahar peak (2,706 feet elevation), in the Sulaipat-Badampahar range, 8½ miles south-west from Okampad. Here again, as at Okampad, a single great lens of ore, roughly figured to be 3,000 feet long by 500 feet broad, with many smaller outliers, occupies the crest of the range, masses

of rich float extending for many hundreds of feet downwards. Six hundred vertical feet were measured from the lowest observed massive outcrop to the highest. The immediate associates of the ore were seen to be banded quartzites and quartz-iron-ore rocks, with abundant rather basic holocrystalline rocks, this time recorded in the field notes as a variety of charnockite. The lower ground to the north-west was again seen to be completely occupied by granite.

Iron-ores of the Drug district, Central Provinces.

The occurrence of valuable iron-ores in the Raipur district was not appreciated before Mr. P. N. Bose briefly referred to the chief deposits in a paper published in the *Records, Geological Survey of India*, Vol. XX, page 167, 1887. The district having been explored again on behalf of Messrs. Tata Sons & Co. by Mr. C. M. Weld, a large area in the Dondi-Lohara Zamindari[1] in the western part of the district was taken up under prospecting license for detailed examination. The iron-ores, on account of their resistance to weathering agents, stand up as conspicuous hillocks in the general peneplain. The most striking of these is the ridge which includes the Dhullee (Dhalli) and Rajhara hills, extending for some 20 miles in a zigzag, almost continuous line and rising to heights of sometimes 400 feet above the general level of the flat country around. The iron-ores are associated with phyllites and are often of the usual type of banded quartz-iron-ore schists characteristic of the Dharwar system. But in places thick masses, apparently lenticular in shape, are formed of comparatively pure hematite, and one of these in the Rajhara hills has been subjected to very careful examination by diamond drilling. The Rajhara mass was carefully sampled across the surface at each point selected for a drill hole and the cores obtained were also analysed in lengths representing successive depths of 10 feet each from the surface, giving altogether 64 samples which were assayed for iron, phosphorus, sulphur, silica and manganese. The average results obtained for the surface samples were as follows:— Fe, 66·35; P, 0·058; S, 0·108; SiO_2, 1·44; Mn, 0·151 per cent.; while for the cores the averages were:—Fe, 68·56; P, 0·064; S, 0·071; SiO_2, 0·71; Mn, 0·175 per cent.

In this mass the prospecting operations thus proved the existence of 2½ million tons of ore carrying about 67·5 per cent.

[1] This portion of the Raipur district has been included in the new district of Drug formed in 1906.

of iron and a phosphorus content only slightly below the Bessemer limit. The quantity estimated is that which may be regarded as ore in sight, while almost certainly much larger quantities may be obtained by continuation of the ore-bodies beyond their proved depth. There are other large bodies of ore in this area which have not been examined in the same detail. These masses of hematite include small quantities of magnetite, but separate determinations of the iron in the ferric state have not been made in order to determine the relative proportions of the two minerals.

Iron-ores of the Jubbulpore district.

In addition to the results of prospecting operations conducted for the Tata Iron and Steel Company in Mourbhanj and the Central Provinces, valuable information has been collected by Mr. E. P. Martin and Professor H. Louis in the Jubbulpore district. Prospecting operations conducted in this area on behalf of the Right Hon'ble Sir E. Cassel showed that while iron-ore is widely distributed and the formations in which it occurs are prominent in the district, there are no rich ore-bodies of large size that could be relied on for an output necessary to maintain an important industry, and most of the ore, being in the form of soft micaceous hematite, would be physically unfit in its natural condition for use in a blast furnace. Generally, also, the ores in this district contain a proportion of phosphorus too high for acid Bessemer steel.

The following analyses, extracted from Messrs. Martin and Louis' report (*Agricultural Ledger*, Calcutta, 1904, No. 3), give an idea of the nature of the ore in the principal occurrences in the Jubbulpore district :—

——	Iron.	SiO_2.	S.	P.	Moisture.
I. *Agaria hill.* Lateritic cap covering most of the hill. 3 samples.	57·58	7·28	0·02	0·125	0·45
	56·85	8·17	0·02	0·125	0·67
	45·67	13·90	0·03	0·187	0·69
Soft micaceous hematitic schists. Ore-layers only. 2 samples.	60·70	7·45	0·019	0·075	0·25
	58·40	8·40	0·022	0·081	0·33
II. *Agaria ridge.* Bed of hematite 4 to 5 feet thick, dipping 50°.	50·07	11·37	0·036	0·074	0·44
III. *Jauli.* Soft, banded hematite-quartz schists. Picked samples.	64·67	3·70	0·027	0·023	0·30
	54·64	16·05	0·033	0·200	0·48
	65·50	3·37	0·032	0·110	0·33
	55·22	17·32	0·030	0·053	0·21

Near Sihora siliceous brown hematites were found poorer in iron but physically more suitable for the blast furnace, and in this area there occur patches of manganiferous iron-ore.[1] The following analyses were obtained from samples obtained at Mansakra (Silondi) near Sihora :—

—	Fe.	Mn.	SiO_2.	S.	P.	Moisture.
Wider band	52·15	0·36	14·70	0·022	0·385	0·10
Narrower band	44·95	6·28	14·55	0·027	0·352	0·27
Manganiferous iron-ore	24·45	21·47	19·60	0·022	0·163	0·80

Mysore.

Mysore State has long had a reputation for possessing unlimited supplies of very high-grade iron-ore, a reputation based partly on the evidence of a once widespread native iron-smelting industry and partly on the reports of observers who have met with numerous large outcrops of highly ferruginous-looking material. But detailed evidence as to the extent and value of the ore-bodies from a commercial point of view is still in a preliminary stage, and is somewhat conflicting. According to notes kindly furnished by Dr. W. F. Smeeth, State Geologist for Mysore, two areas have been examined more carefully during the past two years by officers of the Mysore Geological Department; one of these is in the neighbourhood of Malvalli near the Cauvery Falls in the Mysore district, and the other is the Bababudan Hills in the Kadur district. Near Malvalli are several runs of quartzose rock containing magnetite. A large sample obtained by deepening a number of old workings on two beds of ore, each about 10 to 15 feet thick and steeply inclined, was subjected to magnetic concentration with analysis of the concentrates. From the experiments Dr. Smeeth deduces that large quantities of ore, say, a million tons, and probably several times this amount, could be obtained, yielding 1 ton of concentrates, containing 65 per cent. of iron, for each two tons of ore, at a cost of about 10*s*. per ton of concentrates.

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[1] *Cf.* F. R. Mallet, *Rec. Geol. Surv. Ind.*, XVI, pp. 101-103, (1883).

L. L. Fermor, *Trans. Min. Geol. Inst. Ind.*, I, p. 99, (1906), and *Mem. Geol. Surv. Ind.*, XXXVII, pp. 814, 815, 821-823, (1909).

The Bababudan Hills form a horse-shoe, with the mouth pointed towards the west, the total length round the main chain of hills being about 40 miles. Large quantities of iron-ore crop out throughout the whole length of this range of hills, and numerous samples taken from the escarpments gave averages of 32 to 42 per cent. of iron. An area of 9 to 10 square miles in the neighbourhood of Kalhattigiri on the eastern end of the chain of hills was examined more closely. Over the whole of this area iron-ore exists practically at the surface, with a thin cover of soil and grass over the greater portion. The ore exposed is of fairly high grade, composed chiefly of hematite with some limonite: but, in places, with bands of quartz and containing magnetite. Prospecting pits were dug at various points and the samples obtained analysed. The surface ore is apparently better than that occurring at greater depths; and as a result of his examination, Dr. Smeeth concludes that, out of the 9 or 10 square miles examined, 3 square miles are occupied by good ore. Assuming that the surface ore extends to a depth of at least 10 feet, as seems to be the case, the amount of ore available over this area to this depth is about 83,000,000 tons. The outer crusts, some 3 or 4 feet thick on the average, would yield some 25,000,000 tons of ore containing between 60 and 65 per cent. of iron, and the remaining 6 or 7 feet some 60,000,000 tons of ore containing 55 to 58 per cent. of iron with about 8 per cent. of combined water. The quality of the ore is undoubtedly very good; phosphorus is somewhat high, varying from 0·044 to 0·105 per cent.; but this slight excess of phosphorus over that permissible for first class Bessemer ore would create no difficulty in an electric smelting process such as is under consideration. Dr. Smeeth estimates a cost of 1*s.* 6*d.* to 2*s.* per ton for the ore delivered at works situated at the mines or the foot of the hills.

The native smelting industry.

The indigenous methods of smelting iron have been frequently described for various districts in India, and no new features in the methods have recently been noticed. The industry still persists in a few districts of Bengal, for instance, in the Santal Parganas, Monghyr, Sambalpur, and Orissa; in the Kumaon hills; in Mysore; the districts of Malabar, Salem, and Trichinopoly of Madras; in Hyderabad and in several States in Central India and Rajputana. The industry shows signs of greater activity in the Central Provinces than elsewhere.

The native smelting industry in the Central Provinces.

In the Central Provinces the native smelting industry has been carried on during the five years in no less than 10 districts, one of which, Sambalpur, was transferred to Bengal in 1905. The average number of furnaces at work during the period was 435, the most important districts being Jubbulpore, Raipur, and Mandla, as will be seen from table 46. The quantity of iron produced in these furnaces during the same period is shown in table 46 A, the average annual production being 557 tons for the entire province. This gives an average of the small quantity of 1·28 ton of iron smelted per furnace per year. The production per furnace per annum in the Jubbulpore district is much higher than this, namely 3·75 tons of iron, over half the total production of iron being returned from this district. At one locality, Ghogra, in this district, manganiferous iron-ore is smelted with production of a steely iron known as *kheri*.[1]

TABLE 46.—*Number of Iron-Smelting furnaces at work in the Central Provinces during the period 1904-08.*

DISTRICT.	1904	1905	1906	1907	1908
Saugor	18	21	10	17	13
Jubbulpore	98	129	71	47	38
Mandla	46	51	65	70	58
Narsinghpur	8	3	3	4	6
Chanda	41	14	9	11	5
Balaghat	8	9	7	6	3
Raipur	68	49	173	245	231
Sambalpur	154	(*a*)	(*a*)	(*a*)	(*a*)
Drug	..	..	41	51	58
Bilaspur	..	..	..	..	214
TOTAL .	441	276	379	451	626

(*a*) Transferred to Bengal.

[1] Mem. G. S. I., XXXVII, p. 595.

TABLE 46 A—*Quantity of Iron-ore smelted and Iron produced in the Central Provinces during the period 1904-08.*

YEAR.	Iron-ore smelted.	Metallic iron produced.
	Tons.	Tons.
1904	2,818	699
1905	2,370	675
1906	1,829	483
1907	1,387	339
1908	2,543	592
Average .	2,189	557

The native smelting industry in Garhwal.

Iron-ore occurs at numerous places along the outer Himalaya, the rocks being similar lithologically to some of the Dharwars of Peninsular India. Owing to the abundance of timber and, until recently, the absence of railway transport by which cheap foreign iron and steel have been distributed, the *lohar*, or *agaria* as the native smelter is sometimes called, flourished to a later date than in the more accessible parts of the Peninsula, and the industry of iron-smelting still persists in a languishing condition. The necessity of curtailing the indiscriminate cutting of forests, the readiness with which a large variety of foreign implements can be obtained in the bazars, and the higher wages obtainable on account of the general progress of the country have all combined to encourage the *lohar* to leave his ancestral calling for other industries, although a few workers still occupy their leisure during slack seasons in smelting, and the native-made product is preferred to foreign iron when it can be obtained readily.

In the higher parts of the Garhwal district the fuel used is the charcoal of the *buran* (rhododendron) and *ayas* (oak), while the *chir* tree (one of the pine family) is used in the lower hills. The simple "bloomeries" used are not unlike those generally used on the plains. The purified wrought iron obtained from about one maund (82 lbs.) or ore weighs only about 10 lbs., which, when made up into rough implements like hoes, hammers, and crowbars, sells at about Rs. 3-12 (5*s*.), and to produce this amount labour and

charcoal (1½ maunds) to the cost of Rs. 2-2 (2*s.* 10*d.*) are required. The *lohars* of Garhwal are regarded as belonging to a higher of the low caste *doms*. They regard as the founder of their caste one Kaliya *lohar*, who is supposed to have supplied the Pandvas with their fighting weapons, and he is now propitiated before each smelting operation with an offer of five pieces of charcoal.

Imports.

Except for the pig-iron produced at Barakar (which amounted to 41,919 tons a year during the past five years), practically all the iron and steel used in India is imported; for the steel furnaces in the Government Ordnance Factories and in the East Indian Railway works at Jamalpur are supplied mostly with scrap steel and imported pig, while the iron produced by indigenous methods amounts to only about 1,000 tons a year. The imports of pig-iron averaged 30,974 tons a year during the past five years (1904-05 to 1908-09). The requirements of the country in iron and steel are indicated by the import returns summarised in table 47. From this it will be seen that the total value of the unfinished and finished iron and steel products imported into India has increased from £12,883,879 in 1904 to £22,084,677 in 1908, an increase of 71 per cent. in four years, the average value for the period being £16,910,432. More than half of the increase is due to the increased imports of railway plant and rolling stock, this item accounting for 27·5 per cent. of the total value in 1904 and 38·5 per cent. in 1908.

TABLE 47.—*Imports into India of Iron and Steel Materials during the years 1904 to 1908.*

—	1904.	1905.	1906.	1907.	1908.	*Average.*
	£	£	£	£	£	£
Cutlery and hardware	1,801,529	1,766,118	1,948,439	2,284,873	2,279,854	*2,016,163*
Machinery and mill-work . . .	2,925,260	3,177,623	3,965,381	4,378,969	4,780,485	*3,845,543*
Railway plant and rolling stock .	3,549,020	4,571,313	5,511,943	5,780,086	8,496,408	*5,583,554*
Iron bars, pig-iron, etc. . . .	2,808,897	2,287,365	2,845,404	3,434,645	3,352,963	*2,945,855*
Steel bars, sheets, beams, etc. . .	1,799,173	2,099,606	2,409,387	3,113,361	3,174,967	*2,519,317*
TOTAL .	12,883,879	13,902,115	16,680,554	19,000,934	22,084,677	*16,910,432*

Jadeite.

Exports.

The mineral jadeite, like the true jade (nephrite) with which it is often confused, is especially prized by the Chinese, and the quarrying of the mineral forms quite an important industry in Upper Burma. Some of the mineral raised passes by the overland route into South-West China (Yunnan), but most of it finds its way down to Rangoon, whence it is exported to the Straits Settlements and China. Table 48 shows the extent of this export trade. From this it will be seen that the average annual export during the period under review was 3,911 cwts., as compared with an average figure of 3,470 cwts. for the period of the previous review.

Prices.

The prices paid for rough stone vary too much to permit of an average figure being given, but the export values declared give an idea of the value of the stone; from table 48 it is seen that the value so determined has averaged £17·68 per cwt. during the five years under review, showing a considerable increase as compared with the average value for the previous six years, namely, £11·45 per cwt.

TABLE 48.—*Exports of Jadestone from Burma for the years 1903-04 to 1907-08.* (*a*)

YEAR.	Weight.	Value.	Value per cwt.
	Cwts.	£	£
1903-04	2.775	*59,118*	21·41
1904-05	4.130	*51.615*	12·49
1905-06	2.593	*59,137*	22·80
1906-07	3,852	*62,195*	16·14
1907-08	4.001	*74,402*	18·59
Average	*3,470*	*61.353*	*17·68*

(*a*) Overland trade and exports *viâ* Rangoon combined.

Value of jade.

Amongst prehistoric relics found in various parts of the world, both nephrite and jadeite implements and ornaments are widely distributed, and an admiration for the beauty of the stone, descended from a belief in its magical properties, maintains the value of the mineral in the eyes of the Chinese, who are the chief buyers, and to whom the different varieties of both minerals, and possibly some others, are known under the generic name *Yu-esh*. The softer, serpentinous mineral bowenite passes on the North-West Frontier under the name of *Sang-i-yeshm*. and though its characters are unmistakably distinct from those of nephrite and jadeite, it is evidently regarded as a poor variety of jade.

Composition.

Two distinct minerals are included in the term jadestone or jade, namely, the true *jade* or *nephrite*, which is a silicate of calcipm and magnesium $CaO.3MgO.4SiO_2$, and a member of the amphibole group; and *jadeite*, which is a pyroxene of the composition $Na_2O.Al_2O_3.4SiO_2$ (silicate of sodium and aluminium). They are very similar in colour and other physical properties, but jadeite is slightly the harder and considerably heavier of the two, and is more fusible. They are prized equally by the Chinese. No jade (nephrite) of the kind that would be regarded as a marketable mineral is known in India. But a mineral, having the essential composition and approaching coarse jade in physical characters, is known in South Mirzapur.[1] True jade, however, has been largely worked in the Karakash valley in South Turkestan for many centuries.[2]

Mode of occurrence.

The only jadestone of commercial value found in the Indian Empire is the jadeite found in the basin of the Urû river, a tributary of the Chindwin, in the Mogaung sub-division of the Myitkyina district, Upper Burma. Jadeite is now worked at three localities—Mamon, Hweka, and Tawmaw (25° 44′; 96° 14′). At *Mamon* the jadeite is found in the form of boulders in the alluvial deposits of the Uru river, and also in the bed of the river itself. At *Hweka* the mineral is found in the form of boulders in a conglomerate of Tertiary age. But the most interesting of the three occurrences is at *Tawmaw*. Dr. A. W. G. Bleeck[3] describes the jadeite of Tawmaw

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1 F. R. Mallet, *Rec. Geol. Surv. Ind.*, V, p. 22, (1872).

2 *Cf.* papers quoted by Mallet in Manual, Geol. of Ind., Part IV, p. 85. (1887).

3 "Jadeite in the Kachin Hills," *Rec. Geol. Surv. Ind.*, XXXVI, pp. 254-295, (1908).

as occurring in a metamorphosed igneous dyke intruded into serpentine. He concludes that the jadeite is the result of the metamorphism of an albite-nepheline rock originally forming the dyke. The change would be represented chemically as follows:—

$$NaAlSiO_4 \text{ (Nepheline)} + NaAlSi_3O_8 \text{ (Albite)} = 2NaAlSi_2O_6 \text{ (2 Jadeite)}.$$

Under certain conditions of crystallisation nepheline-albite rock might be formed, while under conditions of high pressure, during consolidation or after, jadeite, which has a much lower molecular volume, would be produced, the residual molecule forming albite or nepheline, according to which molecule was in excess in the original magma. (The albite molecule was the one in excess; for this mineral occurs in a mixed zone of albite and jadeite on each edge of the dyke.) The serpentines form a long ridge flanked on either side by saussuritic gabbros, saussuritic glaucophane-schists, and chlorite-schists. These rocks are traversed by granite and veins of quartz: all the rocks are regarded as genetically related and as the results of the differentiation of the same magma, which gave rise successively to the peridotites, gabbros, nepheline-albite (jadeite) rock, and the siliceous end-products—granite and quartz.

Jadeite has also been found in the Mawlu township of the Katha district.

History of the jadeite trade.

The following notes on the history of the jadeite industry are taken from a copy of the chapter on the jade-mining industry prepared for the Myitkyina District Gazetteer by Mr. W. A. Hertz, and kindly supplied by the Government of Burma. This in its turn is largely based on a report by Mr. Warry of the Chinese Consular Service and is so interesting that a perusal of the full chapter when the Gazetteer is published will well repay the reader for the time spent. In the following paragraphs the term *jade* is used in its generic sense, referring in the case of Burma to jadeite.

According to Mr. Warry, jade-stone or nephrite has been known in China from a period of high antiquity. It was found in Khotan and other parts of Central Asia, the most valued variety being the costly milk-white kind held in high esteem as symbolical of purity in private and official life. The discovery that green jade (jadeite) of fine quality occurs in Northern Burma was made accidentally by a small Yunnanese trader in the thirteenth century,

who, to balance the load on his mule, picked up a piece of stone, which was later found to be jade of great value. For some centuries small pieces of stone found their way across the frontier, but it was not until 1784, after protracted hostilities between Burma and China, that a regular trade was opened between the two countries, and then the Chinese soon discovered the position of the jade-producing district. At the beginning of the nineteenth century the Burmese kings seem to have become aware of the importance of the jade trade and the revenue it might yield, and in 1806 a Burmese Collectorate was established at the site of what is now the town of Mogaung, which became the head of the jade trade in Burma. The Kachins, in whose country the jade deposits are situated, and who were regarded as the absolute owners of all the jade produced, brought the mineral to Mogaung, where it was sold to the Chinese. When it was ready to leave Mogaung an *ad valorem* duty of 33⅓ per cent. was levied and a permit issued. Payments were made in bar silver—at first fairly pure, but later on debased with lead (rupees did not come into general use until 1874).

The period of greatest prosperity of the jade trade was 1831-1840, during which time at least 800 Chinese and 600 Shans were annually engaged in business and labour at the mines. All the stone went by one of several routes to Yunnan-fu, then the great emporium of the jade trade, where Cantonese merchants bought the rough stone and carried it to Canton to be cut and polished. In 1841 war broke out between Great Britain and China and the hostilities at Canton soon affected the jade trade, so that the Cantonese merchants ceased to go to Yunnan-fu to buy stone. Stocks accumulated and Yunnan traders ceased visiting the mines. The trade passed through various vicissitudes, but it was not until 1861 that it really improved again. From that date, when the first Cantonese merchant arrived in Mandalay and made a fortune by buying up all the old stocks of jade, till now, the bulk of the stone has been carried by sea to Canton. During the ensuing years, the jade dues were sometimes collected in the orthodox way—by the Collector at Mogaung—whilst in other years the tax was farmed out; but the King of Burma, dissatisfied with the revenue thus obtained from jade, tried in some years to purchase all the material himself direct from the Kachins at the mines. In such years the Kachins, preferring the former revenue methods, curtailed the output and produced pieces of inferior quality only. The revenue

accruing to the King from the jade dues varied from Rs. 10,000 per annum to Rs. 50,000, being least when the King tried to purchase the jade himself. With the British occupation of Upper Burma the tax was farmed out to Leonpin, who made himself so unpopular by his methods of collecting the tax that he was murdered at Mogaung. The first British visit to the mines was made in 1888 by Major Adamson with a column of British troops. The tax of 33⅓ per cent. on output is still farmed out by Government on triennial leases. It is collected at Mogaung in the case of stone transported on mules *viâ* Kamaing, and at Kindat in the case of stone transported on bamboo rafts down the Uyu and Chindwin.

The amounts realised on account of this farm during the period under review are shown below:—

1903-04	
1904-05	Rs. 50,400 per annum.
1905-06	
1906-07	
1907-08	Rs. 70,800 per annum.
1908-09	

The farm includes also the right to collect the royalty on *amber* at 5 per cent. *ad valorem* in the Myitkyina and Upper Chindwin districts.

In addition to the export duties collected by Government, various dues are levied at the mines by the *Sawbwa* of Kansi, who is the headman of the jade tract.

The actual work of quarrying is carried out by the Kachins during the dry months of the year. At Tawmaw, where the jadeite-rock occurring *in situ* is quarried, considerable difficulty is experienced in extracting the tough rock, and it is found necessary to resort to splitting by fire, it is said to the detriment of the stone. The use of explosives is, however, being adopted.

Magnesite.

Salem district.

The 'Chalk Hills' lying between the town of Salem and the Shevaroy Hills in South India were loosely so named because of the general effect of the network of white magnesite veins, which are prominent over an area of about 4½ square miles. The occurrence

was well known early in the last century, when Mr. J. M. Heath, then 'Commercial Resident' (Collector) at Salem on behalf of the East India Company, was such an energetic prospector. The area was described by W. King and R. B. Foote in 1864,[1] and the origin of the magnesite by alteration of dunite (olivine-rock) was first noticed in 1892.[2]

A more complete account of the area with map and photographs was published in 1896 by C. S. Middlemiss,[3] who drew special attention to the large quantities of mineral easily obtainable.

Attention was directed to the place again by Mr. H. G. Turner, and through his enterprise the Magnesite Syndicate was formed to develop the mineral. A paper by Mr. H. H. Dains recently published[4] demonstrates the high quality of the material obtainable, the magnesite containing 96-97 per cent. of magnesium carbonate in ordinary, and 99 per cent. in picked, samples. The following analyses have been made on fair samples:—

——	Blount.	Dains.	Pattinson (cargo sample).	Ferguson. 1.	Ferguson. 2.
Silica	0·22	0·29	1·17	0·31	1·70
Iron oxide	0·30	0·65	0·14	0·40	0·65
Alumina				0·10	0·10
Manganese oxide	..	0·20	0·06	..	..
Lime	*Nil*	0·83	0·78	..	..
Magnesium oxide	47·35	46·42	46·28	97·80	97·4
Carbon dioxide	51·44	50 71	50·10		
Water	0·27	0 16	1·30	0 60	Traces
Sulphuric acid	..	..	0·03	..	..
Phosphoric acid	..	..	0·01	..	..
TOTAL	**99·58**	**99·26**	**99·87**	**100·06 (*a*)**	**99·85 (*a*)**
Magnesium carbonate	*98·79*	*97·13*	*96·34*	*97·80*	*97·40*

(*a*) Including 0·85 calcium carbonate.

1 *Mem. Geol. Surv. Ind.*, IV, pp. 312-317.

2 T. H. Holland, *Rec. Geol. Surv. Ind.*, XXV, p. 144 footnote.

3 *Rec. Geol. Surv. Ind.*, XXIX, p. 31.

4 'The Indian Magnesite Industry'. *Journ. Soc. Chem. Industry*, XXVIII, p. 503, (1909).

The magnesite is calcined on the spot to produce (*a*) lightly calcined or caustic magnesia, obtained at a temperature of about 800 C., and (*b*) dead-burnt, sintered or shrunk magnesia, obtained by calcination at about 1,700°C. The following analyses, given by Mr. Dains, represent the two products as obtained in gas-fired kilns :—

——	Caustic Magnesia.		Dead-burnt Magnesia.
Loss on ignition	1·82	2·31	0·34
Silica	..	..	4·38
Insoluble residue	1·13	0·54	..
Ferric oxide and alumina	0·63	0·44	1·12
Lime	1·06	1·03	1·04
Magnesia	95·80	96·10	93·12
TOTAL	100·44	100·42	100·00

Experiments made on a considerable scale on behalf of Mr. H. G. Turner[1] showed that when highly heated in an electric furnace the Salem magnesite yields a hard dense crystalline mass of the greatest refractory quality.

Use as source of carbon dioxide.

Magnesite has been largely used as a source of carbonic acid, obtained either by the use of acid or by calcination. As a source of carbonic acid it is superior to ordinary limestone on account of the greater value of the residue and because of the circumstance that its carbonic acid is given off at a much lower temperature in the process of calcination. According to O. Brill,[2] who, however, experimented with artificial and pure materials, magnesium carbonate begins to give off its carbon dioxide at about 237°C. and loses the whole of its gas below red heat at a temperature of about 510°C., while calcium carbonate requires a temperature of 825°C. for complete dissociation.

1 *Jour. Iron.-Steel Inst.*, No. I of 1904, pp. 498-499.

2 *Zeitschr. für anorg. Chem.*, XLV, part 3, pp. 275-292, (1905).

Use as refractory material.

The magnesium oxide in magnesite is used in a great variety of ways, but it is for use as a refractory substance that the Salem magnesite is especially valuable on account of its freedom from the impurities that lower the fusibility of the calcined product, and from lime, which causes the magnesite bricks used to line steel furnaces to disintegrate.

TABLE 49.—*Production of Magnesite in the Chalk Hills near Salem during the years 1904 to 1908.*

YEAR.	Quantity.	Value. (*a*)
	Tons.	£
1904	1,315	*351*
1905	2,063	*550*
1906	1.832	*488*
1907	186	*50*
1908	7,534	*2,009*

(*a*) Value estimated at Rs. 4 a ton for all years.

Production.

The production reported for the 'Chalk Hills' near Salem is given in table 49. Operations were mainly of a prospecting nature for some years, but now that arrangements have been made for calcining on the spot, exploitation has been organised on a larger scale.

Other occurrences.

Magnesite is known to occur at several other places in South India, always as veins traversing peridotites, for example at Seringala in Coorg, on the Cauvery above Fraserpet, in other parts of the Salem district,[1] in the Trichinopoly district, and in the Hassan and Mysore districts of Mysore.[2]

[1] W. King and R. B. Foote, *loc. cit.*, pp. 318-324.

[2] A. Primrose, *Rec. Mysore, Geol. Dept.*, III, p. 239; IV, p. 178:
V. S. Sambasiva Iyer, *op. cit.*, IV, p. 61:
W. F. Smeeth, Report, Chief Inspector of Mines in Mysore, for 1906-07, p. 37.

Manganese.

History.

The rapid development of the manganese-quarrying industry of India referred to in the Review for 1898-1903 has continued at a greatly increased pace during the succeeding five years, so that India now contests with Russia for the first place amongst the world's producers of manganese-ore. The zenith was reached in 1907 with an output of 902,291 tons, the year 1908 witnessing a set-back, owing to the general commercial depression and fall in the demand for steel. The cause of the very large increase in the Indian manganese-ore production for the years 1905, 1906, and 1907, was partly the great activity in the steel trade of the world, and to a smaller extent the political disturbances in the Caucasus, owing to which buyers who once satisfied their wants from the Caucasus were compelled to have recourse to India. The ores found in the Caucasus are soft and friable, and are worked by a large number of small workers, who do not trouble to clean their ores to a uniform standard. Moreover, the railway freights are very high, whilst rolling stock is said to be inadequate. The consequence is that iron masters have found it dangerous to rely too much on the Caucasus for their supplies, and prefer the Indian ore, which is not only more suitable for the blast furnaces, on account of its hard lump form, but is also selected with care by the manganese companies so that the ore exported is of a moderately uniform quality. Hence much of the demand for Indian ore created by the political troubles in the Caucasus is likely to be of a permanent nature. The depression that has come over the Indian manganese industry during 1908 affects the Caucasus also, and is due to a lessened demand for manganese-ore by the steel trade, and not to Russia having recaptured any of its lost custom. This lessened demand was not accompanied by a commensurately smaller production, and the consequence is that there are now large stocks of manganese-ore lying at the mines. The effect of this has been the closing down of a large number of the Indian mines during 1909, only the large mines near the railways being still worked. Towards the end of this year, however, the price of manganese has shown a tendency to rise; but the depression is likely to continue until the revival in the steel trade leads to markedly increased demand for manganese-ore, and even then, the actual work of quarrying cannot be expected to

regain its former magnitude until the accumulated stocks of ore have been disposed of. See also table 50 and figure 12.

Prices.

The effect that market prices have on production can be to some extent gauged by comparing the prices paid per unit for manganese-ore delivered at United Kingdom ports during the quinquennium, as shown in table 50 (from the *Mining Journal*) with the figures of production for the same period shown in table 51 on page 132.

TABLE 50.—*Variation in the Price of Manganese-ore, c.i.f., at United Kingdom Ports.*

DATE.	FIRST-GRADE ORE.	SECOND-GRADE ORE.	THIRD-GRADE ORE.
	50 per cent. Mn. and upwards.	47-50 per cent. Mn.	40-47 per cent. Mn.
	Pence per unit.	*Pence per unit.*	*Pence per unit.*
January 1904	9—9½	8—9	6—8
July 1904	9—9½	8—9	6—8
January 1905	8¾—9¼	7½—8½	6—8
July 1905	9—10	8—9	6—8
January 1906	11—12	9—10½	7—9
July 1906	13—14	11—13	9—11
January 1907	15—16	14—15	13—14
July 1907	14½—15	13½—14	12—13
January 1908	10½	9½	8½
July 1908	9¼	8	7
January 1909	9¼	8¼	7¼
July 1909	9	8	7
January 1910	9½	9¼	9

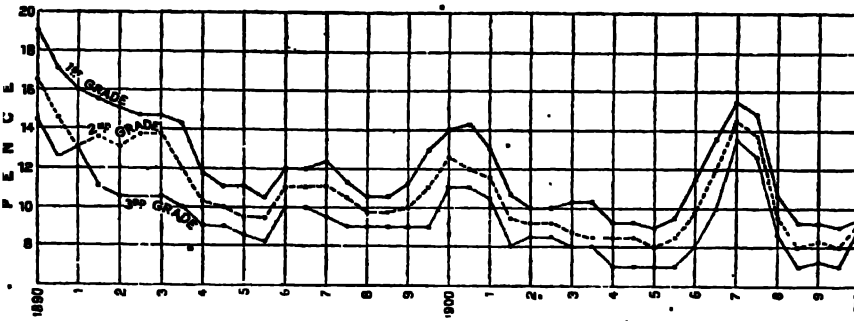

Fig. 12.—*Variation in the Prices of Manganese-ore at United Kingdom Ports since 1890.*

Companies formed.

The great activity of the Indian manganese industry during 1905 to 1907 led to the formation of a considerable number of limited companies to work this mineral. In the period covered by the earlier review, only one limited company was at work—the Vizianagram Mining Company; the two other principal workers being the Central Provinces Prospecting Syndicate and Jambon & Co. During the period now under review the following limited companies have been formed, in addition to numerous small syndicates:—

Bombay—

1. The Shivrajpur Syndicate.
2. The Bamankua Manganese Company.

Central Provinces—

1. The Central India Mining Company.
2. The Indian Manganese Company.
3. The Central Provinces Prospecting Syndicate.

Madras—

1. The General Sandur Mining Company.
2. The Bobbili Mining Company.

Mysore—

1. The Mysore Manganese Company, converted into:—
   The New Mysore Manganese Company and absorbed by:—
   The Workington Iron Company in 1909.
2. The Peninsular Minerals Company of Mysore.
3. The Shimoga Manganese Company.

Other prominent workers during this quinquennium have been :—

The Carnegie Steel Company : Central Provinces.

Jambon & Co. : Bengal, Central Provinces, Goa, Madras, Mysore.

Jessop & Co. : Central Provinces.

Kiddle, Reeve & Co.: Central India.

D. Laxminarayan · Central Provinces.

Madhu Lall Doogar : Bengal, Central Provinces.

Production.

Table 51 shows the production from each district, state, and province during the past five years, and figure 5 on page 21 shows the progress of the industry since its beginning. From this it will be seen that the Central Provinces is by far the most important province as a producer of manganese.

The figures in this table have been compiled from figures obtained direct from the mine operator, showing in most cases the production of each deposit separately. They agree with those given on page 413 of *Mem. Geol. Surv. Ind.*, XXXVII, and are to be taken as superseding figures previously published. They represent, except in a few cases, quantities of ore won or raised, and not of ore railed.

TABLE 51.—*Production of Manganese-ore in India for the five years 1904 to 1908.*

YEAR	BALUCHISTAN	BENGAL.	BOMBAY.			CENTRAL INDIA	CENTRAL PROVINCES.					
		Singhbhum (1906 and 1907), Gangpur (1908).	Belgaum.	Panch Mahals	Total.	Jhabua.	Balaghat.	Bhandara	Chhindwara.	Jubbulpore.	Nagpur.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1904 .	.	..	..	..	.	11,564	10,328	8,559	..	..	66,142	85,024
1905 .	.	.	640	..	640	30,251	16,246	35,238	*Nil*	..	100,063	151,547
1906 .	..	1,000	234	7,286	7,520	50,073	102,260	96,017	7,486	..	146,117	351,880
1907 .	15	2,933	704	22,117	22.821	35,743	163,634	164,208	30,728	7,100	199,352	565,017
1908 .	.	20,000	1,200	22,032	23,232	13,315	135,487	110,673	49,008	48	135,839	431,055
TOTAL .	15	23,933	2,778	51,485	54,213	140,946	427,950	414,690	87,222	7,148	647,513	1,584.523
Provincial Averages	*3*	*4,786*	.	.	*10,842*	*28,189*	..	..	.	..	..	*316,905*

TABLE 51.—*Production of Manganese-ore in India for the five years 1904 to 1908*—continued.

YEAR.	MADRAS				MYSORE.				Totals for whole of India.	*Totals for whole of India.*
	Bellary.	Sandur	Vizagapatam.	Total.	Chitaldrug.	Shimoga.	Tumkur	Total.		
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Statute Tons.	*Metric Tons.*
1904 .	.		53,602	**53,602**	..	..	..	..	**150,190**	*152,601*
1905 .		1,200	63,789	**64,989**	..	..	..	..	**247,427**	*250,788*
1906 .	..	3,209	111,501	**114,710**	712	40,773	4,827	**46 312**	**571,495**	*579,231*
1907 .	3,236	23,050	136,169	**162,455**	3,125	97,091	13,091	**113,307**	**902,291**	*916,770*
1908 .	.	23,413	94,676	**118,089**	3,745	57,696	7,183	**68,624**	**674,315**	*685,135*
TOTAL .	3,236	50,872	459,737	**513,845**	7,582	195,560	25,101	**228,243**	**2,545,718**	*2,581,525*
Provincial Averages	..	..	..	*102,769*	..	..	..	*45,649*	*509,143*	*516,905*

Production of foreign countries.

The growth of the Indian manganese industry during the past five years, and its importance as compared with that of other countries, can be seen from table 52, in which are shown the output figures for the twelve leading countries. The figures have been obtained from various sources.

From this table it will be seen that the three leading countries producing manganese-ore are Brazil, India and Russia. Whilst the Brazilian production has remained fairly constant at about 200,000 metric tons annually during this period, the Indian and Russian outputs have increased enormously; that of India from 152,601 metric tons in 1904 to a maximum of 916,770 metric tons in 1907; and that of Russia from 416,137 metric tons in 1904 to a maximum of 979,554 metric tons in 1906. In 1907 the Indian production approached that of Russia very closely. In 1908 the Russian production fell to 300,000 metric tons, so that India, with an output of 685,135 metric tons, definitely assumed in this year the position so long held by Russia as the leading producer of manganese-ore (see

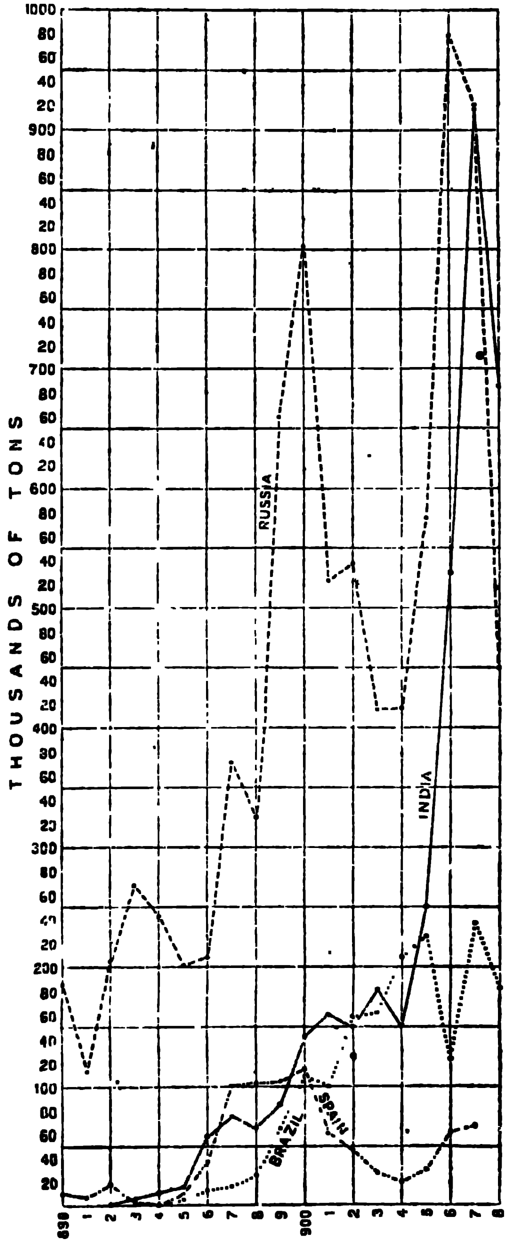

FIG. 13.—*Production of Manganese-ore in the four leading countries since 1890.*

fig. 13). In both countries there was, by the end of 1908, a large accumulation of stocks due to the exports during previous years falling short of the production. But this accumulation of stocks is on a much larger scale in Russia than in India.

Production of manganiferous iron-ore.

In table 53 similar figures are given for the output of manganiferous iron-ores. According to the practice by which all ores containing less than 40 per cent. manganese are classified as manganiferous iron-ores rather than as manganese-ore, a certain, very small, proportion of the Indian production should be classed under this heading. Of the ores mined in the United States, by far the larger proportion is very low in manganese (1 to 8 per cent.).

Exports.

For comparison with the annual figures of production of manganese-ore in India, the export figures during the years 1904-05 to 1908-09 are given below stated separately for each port :—

TABLE 52.—*Annual Production of Manganese-ore by the twelve Leading Producers during the years 1904 to 1908.*

(Metric Tons.)

Year.	Austria.	Brazil.(a)	Cuba.	France.	Greece.	Hungary.	India.	Japan.	Russia.	Spain.	Turkey. (a)	United Kingdom.
1904 . .	10,189.	208,260	15,765	11,254	8,549	11,527	152,601	4,324	416,137	18,732	49,100	8,896
1905 . .	13,788	224,377	7,018	6,751	8,171	9,043	250,788	14,009	575,165	26,020	28,000	14,582
1906 . .	13,402	121,331	18,988	11,189	10,040	10,895	579,231	12,841	979,554	62,822	19,900	23,126
1907 . .	16,800	236,778	34,719	18,200	11,139	8,198	916,770	20,587	921,225	67,977(a)	14,000	16,356
1908 . .	(b)	185,437	(b)	(b)	(b)	(b)	685,135	11,130	300,000	(b)	(b)	6,409

(a) Exports.
(b) Figures not available.

TABLE 53.—*World's Production of Manganiferous Iron-ores from 1904 to 1908.*

(In Metric Tons.)

YEAR.	Germany. (*a*)	Greece.	Italy.	United States.
1904	52,886	239,635	*Nil*	389,396
1905	51,463	89,687	*Nil*	781,592
1906	52,485	96,382	20,500	1,058,018
1907	73,105	92,970	18.874	1,243,483
1908	67.693	(*b*)	(*b*)	539,095

(*a*) Includes a certain amount of true manganese-ore.
(*b*) Figures not available.

TABLE 54.—*Exports of Indian Manganese-ore from April 1st, 1904, to March 31st, 1909.*

(Statute Tons.)

YEAR.	Vizagapatam.	Bombay.	Calcutta.	Mormugao.	Yearly total.
1904-05	52,925	121,015	7,005	..	180,945
1905-06	64,275	236,059	16,360	9,550	326,244
1906-07	106,535	350,543	35,915	61,199	554,192
1907-08	121,735	384,115	42,570	99,962	648,382
1908-09	76,150	336,896	24,967	69,820	507,833(*a*)

(*a*) 14 cwts. returned as exported from Burma referred really to wolfram

From table 55, giving the total Indian production and exports for the years 1892 to 1903 and 1904 to 1908, it will be seen that by the end of 1908 there was an accumulation in India of over 300,000 tons of stocks, as compared with a very small amount of stocks accumulated at the end of the previous five years. Even 300,000 tons, however, is a small amount compared with the stocks, said to be 750,000 to 800,000 tons, of manganese-ore accumulated in the Caucasus; but a large proportion of the Caucasian stocks is said to be of very poor quality.

TABLE 55.—*Comparison of Indian Manganese-ore Production with Exports.*

(Statute Tons.)

PERIOD.	Ore produced.	Ore exported.	Excess of production over exports.
1892 to 1903 .	929,145		
1892-93 to 1903-04		916,386	12,759
1904 to 1908	2,542,482	...	...
1904-05 to 1908-09	...	2,217,596	324,886
TOTAL	3,471,627	3,133,982	337,645

Distribution of Indian manganese exports.

The distribution of the manganese-ores exported from India amongst foreign countries is shown in table 56. The three great steel-producing countries—England, Germany, and the United States—take a large proportion of the Indian manganese-ore; the exports to Holland and Belgium shown in the table were in part for transmission to Germany, whilst the consignments sent to Egypt were booked to Port Said to await delivery at ports further west.

TABLE 56.—*Distribution of exported Indian Manganese-ore for the years 1904-05 to 1908-09.* (a)

(Statute Tons.)

YEAR.	United Kingdom.	Belgium.	France.	Germany.	Holland.	Egypt.	United States.	Other countries.	Total recorded export for the year.
1904-05 .	64,705	25,015	10,800	..	5,300	10,750	64,375	..	180,945
1905-06 .	127,856½	54,101	29,401	2 cwts.	2,400	3,900	96,835	10 cwts. Austria-Hungary 2,200.	316,694
1906-07 .	219,607	98,581	33,485	..	2,000	..	139,320	Austria-Hungary 1 cwt.	493,993
1907-08 .	178,348	137,099	51,889	552	26,252	..	153,380	..	548,420
1908-09 .	151,274	99,344	53,652	164	13,900	..	115,730	Italy 3,950	438,014
TOTAL .	741,790½	415,040	179,227	716	49,852	14,650	569,640	6,150½	1,977,066

(a) Excludes exports *viâ* Mormugao.

Labour.

In Vizagapatam and Mysore an adequate supply of labour seems to be easily obtainable, but in the Central Provinces, Central India, the Sandur Hills, and other parts, labour has frequently to be imported. To relieve themselves of unnecessary trouble and responsibility the mine managers find it preferable to work through contractors, paying them at a given rate per 1,000 cubic feet of stacked and cleaned ore, and for dead-work at a given rate per 1,000 cubic feet of cavity made in the quarry in the case of soft 'deads,' or per 1,000 cubic feet of waste measured in tubs or stacks in the case of hard 'deads.' The daily rates paid to the coolies by the contractors vary between the following limits in different parts of India:—

	Annas.
Men	2½ to 7
Women	1½ to 4
Children	1 to 3

The average daily number of workers during the past five years is shown in table 57.

TABLE 57.—*Daily Number of Workers employed at the Manganese Quarries from 1904 to 1908.*

YEAR.	Bengal.	Bombay.	Central India.	Central Provinces.	Madras. (*e*)	Mysore.	TOTAL.
1904 . .		125	400(*b*)	2,010	1,980		**4,515**
1905 . .		48	876	2,566	2,658		**6,148**
1906 . .	(*a*)	271	1,334	5,154	6,168	1,815	**14,742**(*d*)
1907 . .	900(*c*)	1,198	2,211	9,233	9,651	1,840	**25,033**
1908 . .	900(*c*)	1,231	1,000	12,284	7,114	2,650	**25,179** (*f*)
Average	*360*	*575*	*1,164*	*6 249*	*5,514*	*1,261*	*15,123*

(*a*) Figures not available.
(*b*) Estimated.
(*c*) Roughly 300 persons employed daily in Singhbhum, and 600 in Gangpur during the parts of the year when work proceeded.
(*d*) Exclusive of Singhbhum.
(*e*) Vizagapatam and Sandur, with Bellary in 1907.
(*f*) The increase in the figures for the Central Provinces is due to the inclusion of 3,142 workers in mines not under Mines Act, not obtained in previous years.

The totals in table 57 are in many cases defective, hence, in order to permit of the comparison of the manganese with the coal industry as regards labour, the figures appertaining only to those mines that come under the Mines Act, 1901, are gvien in table 58. From these figures it is seen that the average number of persons employed daily on the manganese mines under the Act has been 11,135, as compared with an average annual output of 383,279 tons of ore. The number of tons of ore won per person employed has averaged 34, as compared with nearly three times this amount in the case of coal (see table 29). The death-rate has been 0·34 as compared with 0·98 in the case of coal; whilst, curiously enough, the number of deaths per million tons won has been almost identical in the two cases, namely, 10·1 for manganese and 10·2 for coal.

TABLE 58.—*Labour Statistics for Manganese Mines under the Mines Act, 1901.*

YEAR.	Average number of persons employed daily.	Production.	Output per head.	Number of deaths.
		(Tons.)	(Tons.)	
1904	4,115	138,733	33·7	1
1905	5,122	204,194	39·9	3
1906	11,273	436,422	38·7	6
1907	18,751	642,082	34·2	4
1908	16,416	494,942	30·1	5
TOTAL .	55,677	1,916,373	..	19
Average .	*11,135*	*383,275*	*34·4*	*3·8*

Cost of mining and transport.

The chief items in the cost of placing manganese-ore on the markets in Europe and America are the following:—

1. Cost of mining (labour, tools, plant, establishment).
2. Cost of transport to the railway.
3. Cost of transport to the port of shipment.
4. Cost of handling at the port of shipment.
5. Cost of shipping to Europe or America.
6. Destination charges.

Each of these six items—the first five of which vary according to the situation of the deposit—has been considered in detail in *Memoirs, Geol. Surv. Ind.*, XXXVII, Chapter XXIII, to which the reader is referred. In table 59 below, however, an abstract is given showing the average cost of delivering, *c.i.f.* at English and continental ports, ore derived from five of the producing areas, namely, the Central Provinces, Jhabua in Central India, Sandur and Vizagapatam in Madras, and Mysore. The figures of most importance are those relating to Central Provinces ore exported *viâ* Bombay. For not only did about two-thirds of the Indian manganese-ore exports for 1906 pass through this port, but 85 per

cent. of this amount was derived from the Central Provinces, from which about 60 per cent. of the Indian production now comes. These figures are also the most accurate. It will be seen that the cost of exporting Central Provinces ore *viâ* Calcutta is considerably higher than for Bombay. This is due to heavier transport charges, owing partly to the longer railway lead to Calcutta than to Bombay, and partly to the unfavourable situation, with regard to the railways, of the deposits the output of which goes to Calcutta. No details are available concerning the ore exported from the Panch Mahals district, Bombay; but it is probable that this ore costs, delivered *f.o.b.* at Bombay, about the same as, or a little more than, that of Jhabua.

TABLE 59.—*Average Cost of Indian Manganese-ore delivered c.i.f. at English and Continental Ports.*

AREA FROM WHICH DERIVED.	Port from which exported.	Average cost per ton. Rs.	A.
Central Provinces .	Bombay	26	14
Ditto .	Calcutta	31	10
Jhabua, Central India	Bombay	22	3
Vizagapatam, Madras	Vizagapatam	23	7
Sandur, Madras .	Mormugao	23	7
Mysore . .	Do.	29	

In the same Memoir some detailed figures are given of the costs of delivering Brazilian and Russian ores *c.i.f.* in London. The total costs are compared with those for Indian ore in table 60. From this it will be seen that with low rates of exchange the Brazilian ores can compete on equal terms with those of India and Russia, but with high rates of exchange Brazilian ores are at a considerable disadvantage. Comparing the Indian and Russian ores it is seen that the Vizagapatam ores cost less to deliver in London than the ores of the Central Provinces and Russia, and that the two latter cost about the same. Assuming the foregoing figures to represent

TABLE 60.—*Comparison of Cost of delivering Brazilian, Russian, and Indian Manganese-ore c.i.f. at London.*

	BRAZIL (MINES GERAES). (*a*)		RUSSIA (CAUCASUS).		INDIA.	
—	At 1,000 milreis = 7 annas.	At 1,000 milreis = 14 annas.	According to Demaret(*b*) (1905).	According to Drake(*c*) (1898).	Central Provinces *viâ* Bombay.	Vizagapatam.
	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
Rupees .	22 15 11	35 9 10	26 9 0	29 6 0	27 4 0	23 11 0
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
Sterling .	1 10 8	2 7 6	1 15 5	1 19 2	1 16 4	1 11 7
Price per unit at which the ore would be sold at no profit or loss.	7·36*d.*	11·4*d.*	8·5*d.*	9·4*d.*	8·7*d.*	8·2*d.*

(*a*) After Demaret, *Annales des mines de Belgique*, X, p. 843, (1905).
(*b*) *Loc. cit.*, p. 886.
(*c*) *Trans. Am. Inst.* Min. Eng., XXVIII, p. 207, (1898).

the average cost fairly, and assuming all the ores to be first-grade, containing 50 per cent. manganese, except the Vizagapatam ore which is assumed to average 46 per cent. Mn and fetch second-grade prices, then the figures given in the last line in table 60 show the price per unit at which the ore would be sold at neither profit nor loss. Since the Russian and Indian ores make up a very large proportion of the world's total production, it follows from these figures that the price per unit of first-grade ore can never fall below about 8½ to 9 pence without automatically so restricting production and export of ore as quickly to send the price back to this level. This is well seen by studying the prices prevailing during 1908 and 1909. By the close of 1908 the price of first-grade ore had fallen to 9¼*d.*; and mining of manganese-ore was in consequence enormously diminished. At the beginning of March 1909 the

price declined further to 9 pence per unit. By October the effects of the increasing activity in the steel-trade and the lessened supplies of manganese-ore were felt and the price rose again to 9½*d.*, with an upward tendency for the lower grade ores also.

Royalties.

In British India the royalty leviable on the base metals is—

'2½ per cent. on the sale value at the pit's mouth or on the surface, of the dressed ore or metal, convertible at the option of the lessee to an equivalent charge per ton to be fixed annually for a term.'

Since it is inconvenient and very difficult to assess the royalties separately for each deposit and producer, it is customary in each area to assume average figures for the composition of the ore and for the costs of mining, transport, etc., and to apply them without distinction to all cases. Table 61 shows the royalties leviable in the Central Provinces according to the market price of first-grade ore. Similar tables could easily be constructed for other areas. In applying them the average price for a period of a year should be used.

TABLE 61.—*Royalties, in Annas per Ton, leviable on Central Provinces Manganese-ore at 2½ per cent. on Pit's Mouth Value.*

1	2	3	4
Price per unit of first-grade ore.	Value of 50 per cent. ore delivered *c.i.f.* at English and Continental Ports.	Pit's mouth value (figures in column 2 minus Rs. 24). (*a*)	Royalty leviable at 2½ per cent. (given to nearest half anna).
Pence.	Rs. A. P.	Rs. A. P.	*Annas.*
8	25 0 0	1 0 0	½
9	28 2 0	4 2 0	1½
10	31 4 0	7 4 0	3
11	34 6 0	10 6 0	4
12	37 8 0	13 8 0	5½
13	40 10 0	16 10 0	6½
14	43 12 0	19 12 0	8
15	46 14 0	22 14 0	9
16	50 0 0	26 0 0	10½
17	53 2 0	29 2 0	11½
18	56 4 0	32 4 0	13

(*a*) Assumed average cost of removing the ore from the pit's mouth and delivering it *c.i.f.* at the port of destination.

In the Native States a fixed royalty irrespective of price is usually arranged when a prospecting license or mining lease is granted. The rates prevailing in certain States are as follows:—

TABLE 62.—*Royalty, in annas per ton, levied in certain Native States and Zamindari lands.*

	Annas.
Jhabua State, Central India	4
Mysore State	6 + 2½ per cent. on profits over 10 per cent. of capital.
Sandur State, Madras	6
The Vizianagram Samasthanum, Madras	4

Valuation of manganese-ores.

From table 50 and the diagram (fig.12) on page 131, it will be seen that the price per unit of manganese, and consequently the price per ton of manganese-ore obtained on its delivery *c.i.f.* at the port of destination, is subject to great variations. The prices given in the table are for the three grades into which manganese-ores are, for commercial purposes, classified:—

1st grade	50 per cent. Mn. and upwards.
2nd „	47-50 per cent. Mn.
3rd „	40-47 per cent. Mn.

As an example of the way in which the schedule of prices is applied we can take the case of a 52 per cent. ore from the Central Provinces in January 1907. The average price at this time was 15½ pence per unit. The price then paid per ton for this ore would be $\frac{52 \times 15\frac{1}{2}}{12} = 67$ shillings and 2 pence per ton = £3-7-2.

The prices quoted in the *Mining Journal*, and given in table 49, apply of course to ore delivered in the United Kingdom; and for this scale to be applicable it was formerly necessary that the ore should not contain more than 10 per cent. of silica and 0·10 per cent. of phosphorus.

Schedule of the Carnegie Steel Company.

In the United States the schedule of prices is fixed by the Carnegie Steel Company and the Illinois Steel Company. According to the schedule given in the 'Mineral Industry' for 1905, published in 1906, the ore must not contain more than 0·1 per cent. of phosphorus, nor over 8 per cent. of silica;

deductions are made from the price of the ore of 15c. per ton for each 1 per cent. of silica in excess of 8 per cent. and of 1c. per unit of manganese for each 0·02 per cent. of phosphorus in excess of 0·1 per cent. The price per unit of manganese given in this publication is as follows :—

Over 49 per cent. of Mn	28 cents.
46—49 per cent. of Mn	27 „
43—46 per cent. of Mn	26 „
40—43 per cent. of Mn	25 „

Ore containing less than 40 per cent. of manganese, or phosphorus, or silica in excess of the above limits, is sometimes subject to acceptance or refusal at the buyer's option. An additional price per unit of iron present in the ore is sometimes paid by the steel-makers; but the practice as regards this constituent varies. Settlements are based on the analysis of samples dried at 212° F., the moisture being deducted from the weight of the ore. In the 'Mineral Industry' for 1903, issued in 1904, where the price per unit of manganese for ores containing over 49 per cent. of this constituent is given as 25c., the price paid by the Carnegie Steel Company for each unit of iron is given as 5c.

Requirements made less stringent during 1906.

Owing, however, to the rise in prices during 1906, and the great difficulties steel-makers are said to have encountered during this year in obtaining the full amounts of ore required, there has been a tendency for a slackening in the stringency of the requirements of the steel-makers, especially as regards manganese and phosphorus contents. It is probable that a considerable proportion of these restrictions are not always closely connected with any metallurgical difficulties in the treatment of the ores, but with the desire of the steel-makers to obtain their supplies of manganese-ore at as favourable a price as possible, and to be able to cut down the prices paid whenever possible by levying fines for the presence of a small percentage of a given constituent in excess of what is stated in their schedule of prices. That this is probably the true interpretation of the situation is shown by the fact that during 1906, under the influence of the great demand for Indian ores, it seems to have been possible to find a market for almost every variety of ore that could be obtained, except the very siliceous ones,

There has for some years been a steady demand for the ores of Vizagapatam, ranging in phosphorus from 0·25 to 0·45 per cent., and for the Jhabua ores averaging 0·20 per cent. of phosphorus. During 1905 and 1906 a market was also found for Vizagapatam ores containing between 30 and 40 per cent. of manganese; and during 1907 some of the ores from Shimoga in Mysore, for which a market was found, ran as low as 30 per cent. in manganese. The constituent that seems to be of much more importance than the phosphorus as a deleterious constituent is the silica, and we have not heard of any contracts made for the supply of Indian manganese-ores containing over 10 per cent. of this constituent.

According to John Birkinbine,[1] the requirements of the Carnegie Steel Company and the Illinois Steel Company were made less stringent in a schedule issued in December 1905. The permissible phosphorus limits were raised to 0·25 per cent. and the silica limits left at 8 per cent. The deductions to be made were 15 cents per ton of ore for each 1 per cent. in excess of 8 per cent. of silica, and 2 cents per unit of manganese for each 0·02 per cent. or fraction thereof in excess of 0·25 per cent. of phosphorus. Ores containing less than 40 per cent. manganese or more than 12 per cent. silica or 0·27 per cent. phosphorus to be subject to acceptance or refusal at the buyer's option. The price per unit of manganese is 2 cents higher all round than in the schedule given on page 144, and price per unit of iron 6 cents instead of 5. This schedule was in force till July 1st, 1908, when, owing to the fall in prices, it was withdrawn.

Valuation for chemical purposes.

The prices noticed above are those relating to manganese-ores intended for use in the iron and steel industry. For ores suited for use in the chemical industries as oxidising agents much higher prices are often obtained. For chemical purposes it is not the percentage of manganese that is of importance, but the percentage of oxygen liberated on treating the ore with acid, *i.e.*, the *available oxygen*. This is usually expressed in terms of the percentage of manganese peroxide, MnO_2. Not only does the percentage of MnO_2 affect the price, but also the ease with which the oxygen is liberated. Further, impurities that are soluble in acid and so cause an unnecessary consumption of it

1 'Mineral Resources of the United States' for 1905, published in 1906.

are deleterious. The best minerals for these purposes are pyrolusite. psilomelane, and hollandite. For the glass industry the ore must be as free as possible from iron. The only Indian pyrolusite yet found sufficiently pure for the glass industry is that of Pali in the Nagpur district. A picked specimen of this giving 95·57 per cent. MnO_2 showed only 0·06 per cent. Fe_2O_3. To show the high prices given for ores sold for their percentage of peroxide, the following figures are quoted from the *Engineering and Mining Journal* for August 3rd, 1907, page 236 ; they refer to crude powdered ore.

TABLE 63.—*Prices of Manganese-ores sold for Peroxide.*

Percentage of MnO_2.	Cents per pound.	Equivalent sterling price per ton.
		£ s. d. £ s d
70—75	1¼—1½	5 16 8 to 7 0 0
75—85	1½—2	7 0 0 to 9 6 8
85—90	1¾—5	8 3 4 to 23 6 8
90—95	6½	£30-6-8

The price is sometimes as high as 20c. per lb.

Nomenclature of manganese-ores and manganiferous iron-ores.

It is customary to divide the ores of iron and manganese into iron-ores. manganiferous iron-ores, and manganese-ores. The least percentage of manganese in an iron-ore that is usually paid for is said to be 5 per cent., and with less than 5 per cent. of manganese it hardly seems necessary to prefix the adjective 'manganiferous.' The dividing line between manganiferous iron-ores and manganese-ores was formerly taken at 44 per cent. manganese (=70 per cent. MnO_2). Later, ores with as little as 40 per cent. manganese have been termed manganese-ores, and those below this limit manganiferous iron-ores. According to this method one often sees an ore referred to as manganiferous iron-ore that contains much more manganese than iron. Such a difficulty can easily be avoided by creating a class for *ferruginous manganese-ores*. Accordingly, in *Memoirs, Geol. Surv. Ind.*, XXXVII, page 500 (1909), the following

classification has been proposed. It is applicable to all ores containing over 50 per cent. of Mn + Fe.

—	Mn per cent.	Fe per cent.
Manganese-ores	40—63	0—10
Ferruginous manganese-ores	25—50	10—30
Manganiferous iron-ores	5—30	30—65
Iron-ores	0 5	45—70

Analyses of manganese-ores.

On pages 501 to 509 of the work cited above a series of tables of analyses of Indian ores will be found. A good idea as to the quality of the ores obtained in different parts of India can be gleaned from the range and mean values of these analyses summarized in the two tables (64 and 65).

Analyses of Indian ores expected by buyers.

For comparison with the figures given in table 64 we give in table 66 figures, obtained from a reliable source, showing the range in the composition of the ores that buyers expect to obtain when contracting for the purchase of various Indian ores. It will be seen that they agree very well, with one or two exceptions, with the figures given in table 64. The most marked exception is the Panch Mahals. The figures given in table 64 are probably lower than would be obtained in practice, because the samples were taken from the outcrop without any selection, such as would naturally take place when the ores were worked. Some of these samples are, moreover, probably from parts of the outcrop that it has not been found profitable to work.

Analyses of cargoes of Indian and foreign ores landed at Middlesborough.

In order to show the value of the Indian ores relative to those of foreign countries two tables (67 and 68) are given below showing the limits and averages, respectively, of a large number of cargoes of manganese-ores and manganiferous iron-ores landed during the years 1897—1906 at Middlesborough. They represent not only Indian manganese-ores, but also the

TABLE 64.—*Range of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	BENGAL.		BOMBAY.					CENTRAL INDIA.	CENTRAL PROVINCES.		
DISTRICT.	SINGHBHUM.		BELGAUM. (a)		DHARWAR (SANGLI). (b)	PANCH MAHALS.	SATARA.	JHABUA.	BALAGHAT.	BHANDARA.	CHHINDWARA.
Class of ore.	Manganese-ore.	Manganiferous iron-ore.	Manganese-ore (some ferruginous).	Manganiferous iron ore.	Ferruginous manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.
Number of analyses.	3	3	10	2	10	4	4	5	13	13	9
Manganese .	46·80—48·08	4·23—20·66	31·20—60·85	8·34—12·84	19·45—38·48	30·20—49·35	37·58—45·62	44·29—48·40	49·08—54·51	49·00—54·07	48·95—54·97
Iron .	1·22— 6·10	25·60—41·30	0·10—19·38	47·22—51·88	13·3 —25·3	3·05— 6·25	4·40— 9·25	5·86—10·40	5·28— 9·10	3·86—10·25	5·09—11·77
Silica . .	2·45— 8·30	14·70—18·10	0·65— 2·50	1·85— 2·70	7 —31	2·80—40·65	2·90— 4·75	5·85—11·25	1·62— 6·02	2·08— 6·50	4·98—10·63
Phosphorus .	0·27— 0·42	0·35— 1·18	0·01— 0·12	0·02— 0·025	..	0·16— 0·25	0·04— 0·10	0·165— 0·27	0·04— 0·24	0·06— 0·34	0·06— 0·28
Moisture .	0·55— 0·88	1·00— 1·40	..	..	..	0·30— 0·40	1·70— 2·50	0·20— 0·75	0·12— 0·85	0·09— 1·00	0·00— 1·27

(a) From analyses, by Messrs. Pearson of London, supplied by Mr. C. Aubert.

(b) From analyses, by Major Collis Barry, supplied by the Bombay Company, Ltd.

TABLE 64.—*Range of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India*—continued.

PROVINCE	CENTRAL PROVINCES—*contd.*				MADRAS.					MYSORE.		
										SHIMOGA.		
DISTRICT.	NAGPUR.	JUBBULPORE.			GANJAM.	SANDUR. (*a*)	VIZAGAPATAM.			New Mysore Manganese Company. (*b*)		Shimoga Manganese Company. (*c*)
								Supplied by Vizianagram Mining Company.		Manganese-ore.		
Class of ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.	Ferruginous manganese-ore	Manganese-ore and ferruginous manganese-ore.	Manganese-ore and ferruginous manganese-ore.	Manganese-ore.	Ferruginous manganese-ore.	Higher grade.	Lower grade (ferruginous).	Manganese-ore and ferruginous manganese-ore.
Number of analyses.	30	3	7	4	1	6	12	8	7	..	..	9
Manganese	42·28—56·52	34·53—56·80	6·20—25·60	0·16—1·70	28·44	39·47—54·39	32·21—49·05	41·45—49·69	35·43—38·51	44—56	30—44	34·51—55·04
Iron	2·09—16·34	1·60—10·30	19·17—47·10	42·08—59·90	19·70	5·38—19·40	4·80—15·70	2·35—12·90	12·87—19·32	2—10	10—20	4·01—17·25
Silica	2·90—18·48	1·40—4·79	4·40—23·40	5·21—20·40	10·25	0·43—1·00	1·10—10·30	3·05—5·70	4·93—6·90	1—3	2—6	0·22—5·75
Phosphorus	0·04—0·65	0·03—0·46	0·02—0·85	0·04—0·48	0·71	0·02—0·03	0·13—0·48	0·26—0·45	0·20—0·45	0·15—0·06	0·01—0·06	0·01—0·14
Moisture	0·11—1·32	0·39—0·90	0·12—0·65	0·29—0·38	2·55	..	0·50—1·35	..	..	about 1	about 1	..

(*a*) From analyses, supplied by Mr. C. Aubert.
(*b*) Estimated figures by Mr. C. S. Fawcitt.
(*c*) From analyses, by various chemists, supplied by Miss A. E. Dawson.

TABLE 65.—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the various Districts and Provinces of India.*

PROVINCE.	BENGAL.		BOMBAY.					CENTRAL INDIA.	CENTRAL PROVINCES.						
DISTRICT.	SINGHBHUM.		BELGAUM.		DHARWAR (SANDUR).	PANCH MAHALS.	SATARA.	JHABUA.	BALAGHAT.	BHANDARA.	CHHINDWARA.	NAGPUR.	JUBBULPORE.		
Class of ore.	Manganese-ore.	Manganiferous iron-ore	Ferruginous manganese-ore	Manganiferous iron-ore.	Ferruginous manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.
Number of analyses.	3	3	10	2	10	4	4	5	13	13	6	30	3	7	4
Manganese .	47·66	11·84	44·77	10·53	31·62	41·08	40·79	46·94	51·88	51·94	52·72	51·53	45·56	20·26	0·96
Iron . .	2·90	34·93	10·33	49·55	16·8	4·07	6·94	8·44	7·40	7·27	7·08	6·24 ([illegible])	4·79	28·78	50·50
Silica . .	4·63	16·46	1·40	2·27	19·1	19·11	3·75	8·14	3·74	4·59	7·16	7·25	2·68	12·99	10·76
Phosphorus .	0·34	0·74	0·035	0·023	..	0·20	0·07	0·20	0·11	0·14	0·14	0·11	0·215	0·25	0·32
Moisture .	0·63	1·17	..	..		0·35	1·99	0·43	0·37	0·44	0·38	0·49 ([illegible])	0·56	0·3	0·33
Manganese + Iron .	50·56	46·77	55·10	60·08	48·42	45·75	47·73	55·38	59·28	59·21	59·80	57·77	50·35	49·04	51·40

TABLE 65.—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the various Districts and Provinces of India*—continued.

PROVINCE.	MADRAS.					MYSORE.		
						SHIMOGA.		
DISTRICT.	GANJAM.	SANDUR.	VIZAGAPATAM.			New Mysore Manganese Company.		Shimoga Manganese Company.
Class of ore.	Ferruginous manganese-ore.	Ferruginous manganese-ore.	Ferruginous manganese-ore.	Supplied by Vizianagram Mining Company.		Ferruginous manganese-ore.		Manganese ore.
				Manganese-ore	Ferruginous manganese-ore.	Higher grade.	Lower grade.	
Number of analyses.	1	6	12	8	7	3	Half the limits.	9
Manganese . . .	28·11	47·75	42·96	44·34	36·75	46·75	37	49·10
Iron	19·70	11·45	11·22	9·08	15·20	10·06	15	7·74
Silica . . .	10·25	0·61	4·20	4·15	5·72(?)	1·77	4	2·62
Phosphorus . . .	0·71	0·030	0·27	0·32	0·335	0·031	0·035	0·085
Moisture . . .	2·55		0·90		..	0·95	1	..
Manganese + Iron . .	48·11	59·20	54·18	53·42	51·95	56·81	52	56·84

manganese-ores of the Caucasus, Brazil, and Chile, and the manganiferous iron-ores of Greece and Spain (*viâ* Carthagena). From these figures it will be seen that the Indian ores contain less moisture than those of the other countries. Some of the latter contain such large quantities of moisture—Caucasus, 8·67 per cent.; Brazil, 11·35 per cent.; and Spain, 8·44 per cent.—that it is necessary to reduce the analyses to their condition when dried at 100°C. before any fair comparison can be made. This has been done by assuming that the constituents of the ores not given in the 'as received' columns would if determined make the analyses add up exactly up to 100. From the figures representing the dried ores it will be seen that the Indian ores stand first as regards manganese contents, with Brazil a

TABLE 66.—*Analyses of Indian Manganese-ores for which Buyers stipulate when making contracts.*

PROVINCE.	BOMBAY.	CENTRAL INDIA.	CENTRAL PROVINCES.				MADRAS.		MYSORE.
DISTRICT.	PANCH MAHALS.	JHABUA.	NAGPUR, BALAGHAT, AND BHANDARA.	NAGPUR AND BHANDARA		NAGPUR.	SANDUR	VIZAGAPATAM.	SHIMOGA.
Shipping firms.	Shivrajpur Syndicate, Ltd.	Kiddle, Reeve & Co.	Central Provinces Prospecting Syndicate.	Central India Mining Company, Ltd.		Indian Manganese Company, Ltd.	Jambon & Co.	Vizianagram Mining Company, Ltd.	Mysore Manganese Company, Ltd., and the Madras Mining Syndicate.
				First grade.	Second grade.				
Manganese	51—52	46—48	52—54	51—52	46—48	50—52	44—46	45—47	46—47
Iron	6—8	4—7	4—6	6—7	6—8	5—6	11—16	12—14	9—10
Silica	5—6	8—9	6—7	7—8	9—11	6—8	2—4	3—4	3—4
Phosphorus	0·17—0·18	0·13—0·16	0·07—0·08	0·09—0·11	0·12—0·17	0·11—0·14	0·05—0·06	0·26—0·33	0·04—0·05

close second: as regards silica, Brazil stands first, with India second: as regards phosphorus, however, India stands last but one, the only ores containing more phosphorus being those of Russia: the Indian ores contain much less iron than the manganiferous iron-ores of other countries; but of the true manganese-ores they contain the highest amounts of iron, in spite of the fact that they also contain the highest amounts of manganese. The high iron contents of the Indian ores may be regarded as a point in their favour, or otherwise, according to the use to which the ores are to be applied. It is true that the high iron contents makes it more difficult to manufacture the very highest grades of ferro-manganese from the Indian ores; but, on the other hand, if the very highest grades are not required, then the iron is of considerable value. Both manganese and iron are of use in this case, and the buyer obtains the following totals of Mn + Fe when he buys the ores of the different countries:—

	Mn + Fe Per cent.
India	57·17
Brazil	54·09
Russia	50·41
Chile	48·40
Greece	47·99
Spain	44·27

As regards phosphorus, the figures for the Indian ores are rather misleading; for an examination of the analyses from which these figures have been taken shows that the ores consist of two different varieties. The majority of analyses are typical of the ores of the Central Provinces, whilst four of them probably represent ores from the Vizagapatam district. I have accordingly separated them into two groups, of which the mean values are given in table 69. From these figures it will be seen that the Central Provinces ores average 0·096 per cent. and the Vizagapatam ores 0·291 per cent. in phosphorus.

Value of the Indian manganese-ore production.

The valuation of the Indian manganese-ore production is a question of some interest. There are of course several ways of stating the value. Manganese-ore possesses one value per ton as stacked at the pit's mouth, another as delivered *f.o.r.* at the railhead, a third as delivered *f.o.b.* on board the ship

TABLE 67.—*Limits of Analyses of Cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesborough during the ten years 1897 to 1906.*

COUNTRY.	INDIA.	RUSSIA (CAUCASUS).	BRAZIL.	CHILE.	GREECE.		SPAIN (*vid* CARTHAGENA).
Class of ore.	Manganese-ore.	Manganese-ore	Manganese-ore.	Manganese-ore.	Manganiferous iron-ores. *Raw.*	Manganiferous iron-ores. *Calcined.*	Manganiferous iron-ores.
Number of cargoes.	26	77	25	9	51	18	24
Period.	1900—1906.	1898—1906.	1898—1906	1898—1903.	1897—1906.	1897—1903.	1897—1905.
Manganese	42·13—54·53	40·74—48·98	37·05—48·14	46·44—49·56	8·63—24·44	10·41—23·21	7·32—21·78
Iron	3·85—11·69	0·38—0·93	2·55—8·26	0·25—0·52	18·96—42·75	26·55—43·75	16·38—40·75
Silica	2·63—9·99	6·91—13·06	0·80—7·78	6·12—9·16	2·59—11·52	5·35—9·70	6·50—17·97
Phosphorus	0·05[illegible]—0·331	0·095—0·17	0·017—0·130	0·009—0·018	0·012—0·044	0·015—0·038	0·007—0·022
Moisture	0·21—2·64	5·67—12·35	2·69—19·57	0·54—2·13	0·56—8·74	..	4·07—13·78
Alumina, siliceous matter, etc.	3·63—13·18	8·97—15·58	0·92—12·80	11·92—13·47	2·74—12·13	6·20—10·80	6·18—19·52

TABLE 68.—*Mean of Analyses of Cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesborough during the ten years 1897 to 1906.*

COUNTRY.	INDIA.		RUSSIA (CAUCASUS).		BRAZIL.		CHILE.		GREECE.			SPAIN (*viâ* CARTHAGENA).	
Class of ore.	Manganese-ore.		Manganese-ore.		Manganese-ore		Manganese-ore		Manganiferous iron-ores. *Raw.*		Manganiferous iron-ores. *Calcined.*	Manganiferous iron-ores.	
Number of cargoes	26		77		25		9		54		18	24	
Period.	1900—1906.		1898—1906.		1898—1906.		1898—1903.		1897—1906.		1897—1903.	1897—1905.	
Method of reporting analysis.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	As received.	Dried at 100°C.	Dried at 100°C	As received.	Dried at 100°C.
Manganese . . .	50·49	50·86	45·28	49·58	44·60	50·314	47·51	47·99	15·15	16·96	43·01	19·35	21·13
Iron	6·26	6·31	0·76	0·83	3·35	3·78	0·41	0·41	29·54	31·03	41·32	21·19	23·14
Silica	5·67	5·71	9·29	10·17	1·81	2·04	7·26	7·33	7·37	7·74	7·33	11·18	12·21
Phosphorus . . .	0·126	0·127	0·147	0·161	0·046	0·052	0·017	0·01	0·022	0·023	0·023	0·013	0·014
Moisture . . .	0·72	..	8·67	..	11·35	..	1·01	..	4·79	..	..	8·44	..
Alumina, siliceous matter, etc. . . .	6·75	6·80	11·66	12·77	2·73	3·08	12·52	12·65	8·04	8·44	8·35	12·63	13·79

TABLE 69.—*Mean of Analyses of Indian Ores in Table 67 arranged according to Probable Source*

Source of ore.	Central Provinces, and possibly Jhabua and Panch Mahals	Vizagapatam.
Number of cargoes.	22	4
Manganese	51·31	45·95
Iron	5·53	10·29
Silica	6·13	3·10
Phosphorus	0·096	0·291
Moisture	0·71	0·76

at the port of shipment, a fourth as delivered *c.i.f.* at the port of destination, and a fifth after it has been converted into ferro-manganese. For example, with the price at fourteen pence per unit, the average value of Central Provinces ore may be taken as :—

Rs.	A.	
19	10	at the pit's mouth.
21	2	*f.o.r.*
30	12	*f.o.b.*
43	12	*c.i.f.*

The question of values is discussed at length in *Memoirs, Geol. Surv. Ind.*, Vol. XXXVII, Chapter XXV, and it is there shown that to obtain a true idea of the value of the industry to India the export or *f.o.b.* values must be considered. But it is also pointed out that the true value of the ore in the world's markets is the *c.i.f.* value. The export values hitherto given have been obviously much too low; they were based on figures supplied by the mine operators, and represent, apparently, the cost of winning the ore and placing it on board a ship at the port, and not the true value of the ore,

which is the foregoing figure *plus* the profit. In the work already cited the export values have been re-calculated from the beginning of the industry. First the *c.i.f.* values per ton have been calculated separately for each area, on the basis of the average market price per unit of manganese-ore during the year, and an assumed average composition of the ores. From these *c.i.f.* values the *f.o.b.* values are obtained by deducting Rs. 14 from the *c.i.f.* value per ton. The *f.o.b.* value per ton is then multiplied by the actual production for the year. The figures thus calculated for the years 1904 to 1908 are given in table 70.

Usually the amounts of ore won and exported are not very different; but during some years, such as 1907 and 1908, the amounts of ore won exceed greatly the amounts of ore exported and the totals obtained as above are considerably more than the total values actually obtained by the mining community. As figures for the amounts of ore exported are not obtainable in detail province by province the totals may be adjusted for these years by valuing the exports for the calendar years ending 31st December at the average value per ton derived from the total production. Treated in this way the total values for 1907 and 1908 become—

	£
1904	142,443
1905	262,696
1906	874,499
1907	1,361,996
1908	517,166

and these figures have been used in the table of total values (table 1, page 9).[1]

But it must be remembered that stocks of ore left on the mines will be exported in later years, so that it is better to take the totals given in table 70 as representative of the true values.

Comparing the export values of the manganese-ore production with the values for the other chief Indian mineral products given in table 1 it will be seen that manganese stands third in order of value.

1 The weights of ore valued are exports for calendar years from Bombay, Calcutta, and Vizagapatam, and for fiscal years from Mormugao, figures for calendar years not being available in the last case.

TABLE 70.—*Export Values, f.o.b. at Indian Ports, of the Manganese-ore produced in India in the years 1904 to 1908.*

YEAR.	Baluchistan.	Bengal.	Bombay.	Central India.	Central Provinces	Madras.	Mysore.	Totals.	Totals sterling.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	£
1904 .	..	..	..	1,43,827	13,65,698	5,59,471	..	20,68,996	137,933
1905 .	..	..	290	2,87,384	24,34,223	6,29,581		33,51,478	223,432
1906 .	..	21,250	2,08,548	10,64,072	1,05,12,414	17,13,174	10,16,673	1,45,36,131	969,075
1907 .	296	75,158	7,07,543	9,15,914	1,97,16,188	36,39,214	30,65,337	2,71,19,650	1,807,977
1908 .	..	3,26,250	3,70,497	1,53,955	75,43,018	11,88,151	8,90,798	1,04,72,669	698,178
TOTALS	296	4,22,658	12,86,878	25,65,152	4,05,71,541	77,29,591	49,72,808	5,75,48,924	3,836,595
Averages	*59*	*84,532*	*2,57,376*	*5,13,030*	*81,14,308*	*15,45,918*	*9,94,562*	*1,15,09,785*	*767,319*

Other economic considerations.

Reviewing the course of the manganese industry in India during the past five years, it may be said that there has been an enormous expansion of the industry. As the industry has sprung up in new areas the methods of work have as a rule been very crude at the beginning: but the general tendency has been, as knowledge concerning this mineral substance and its mode of occurrence became more generally disseminated, towards a distinct improvement in the standards of work. An account of the methods of work at present in vogue in India will be found in *Memoirs*, Vol. XXXVII, Chapter XXVII. In many cases, especially in Vizagapatam and the Central Provinces, the limits of open-quarrying are being rapidly approached, so that in some cases it will be necessary, in the near future, either to resort to underground mining or to abandon the deposits. There is every reason to believe that in many cases, especially in the Central Provinces, the ores continue to some depth with a quality good enough to be worth while following by underground mining; but any given deposit, before it is developed in this way, should be tested carefully by means of bore-holes to the depth to which it is desired to work it by underground methods. A beginning has been made in opening up the lower portions of the deposit forming Mansar Hill by a series of drives and winzes, but this is the only example.

A feature of the industry to which attention may be directed is the waste of smalls and low-grade ores that takes place in the Central Provinces, where large quantities of high-grade lump ores can easily be obtained. In years to come there may be a demand for lower-grade ores than are now exported, and it would not be much extra trouble to stack separately from the waste the low-grade ores not at present exported, in anticipation of the time when such ores may be of value. The smalls and dust-ore so abundant at many of the deposits would undoubtedly be considered worth saving at many localities outside India where manganese-ores are worked.

The loss that India suffers through exporting its manganese-ore in the raw condition, instead of manufacturing at least a portion of it into ferro-manganese, has already been referred to in a previous review (page 62). Although the question of manufacturing this commodity in India has, in the last few years, received some attention from business men, nothing tangible has yet resulted. The feasibility of such a project is considered at some length in *Memoirs, Geol. Surv. Ind.*, Vol. XXXVII, Chapter XXVIII, pages 584—590 (1909).

Geological relations of Indian Manganese.

The manganese industry has now assumed such importance in India that it is proposed to give below a brief sketch of the distribution and mode of occurrence of the Indian deposits. Those deposits of economic value can be divided into three main groups.

(*A*) Deposits associated with a series of manganiferous intrusives known as the *kodurite series*. Found in—

Madras :—Ganjam, *Vizagapatam*.

(*B*) Deposits associated with rocks of Dharwar age—the manganiferous facies of which is known, when containing spessartite-garnet, as the *gondite* series. Found in—

Bengal :—*Gangpur*.
Bombay :—Narukot, *Panch Mahals*.
Central India :—*Jhabua*.
Central Provinces :—*Balaghat*, *Bhandara*. *Chhindwara*, *Nagpur*, and Seoni.

(*C*) Deposits occurring as *lateritoid* replacement masses on the outcrops of Dharwar rocks. Found in—

Bengal :—*Singhbhum.*
Bombay :—Dharwar, North Kanara.
Central Provinces :—*Jubbulpore.*
Goa.
Madras :—*Bellary, Sandur.*
Mysore :—*Chitaldrug, Kadur, Shimoga, Tumkur.*

Italics denote that ore has been worked for export.

In addition to the occurrences noted above, ore has been worked in the low-level laterite of Goa and the high-level laterite of Belgaum (though this occurrence—Talevàdi—might perhaps be more accurately classed with the lateritoid occurrences). Manganese-ores have also been found in many other districts in India, but none of these other occurrences have been shown to be of any value. Amongst them, the following may be mentioned :—

In Bijawar rocks :—Dhar, Gwalior, Indore, Hoshangabad.
In Vindhyan rocks :—Bhopal.
In Kamthi rocks :—Yeotmal.
In Lameta rocks :—Dhar, Indore, Nimar.
In lateritic soil on the Deccan Trap :—Satara.

Each of the three chief groups will now be considered in turn.

A.—The Kodurite Group.

Kodurite series.

The kodurite series[1] is developed typically in the Vizagapatam district, where it occurs associated with other Archæan crystalline rocks, the chief groups of which are the khondalite series including the calcareous gneisses, the gneissose granite, and the charnockite series. The kodurite series is held to be of igneous origin, and probably of later age than the khondalite series, which is the series with which it is closest associated. The original koduritic magma has been differentiated into a series of rocks ranging from very acid (quartz-orthoclase-rock) through basic (kodurite) to ultra-basic (spandite-rock and manganese-pyroxenites). The typical rock, *kodurite,* is composed of potash-felspar, spandite (a garnet intermediate in composition between spessartite and andradite), and apatite.

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1 *Mem. Geol. Surv. Ind.*, XXXVII, Chaps. XII., XIII. (1909); *Rec. Geol. Surv. Ind.*, XXXV, p. 22 (1907).

The manganese-bearing minerals contained in these rocks are spandite, rhodonite, and two or three other manganiferous pyroxenes, at present unnamed. Subsequently, the whole series of rocks has been chemically very much altered with the production from the felspars of enormous masses of lithomarges and, from the manganiferous silicates, of manganese-ores. Other secondary products are chert, ochres, and wad.

Vizagapatam: mode of occurrence.

The manganese-ore bodies thus formed are often extremely irregular both in shape and size, often showing no definite strike or dip. But in other cases, as at Garbham, the ore-bodies have a well-marked dip and strike, and apparent bedding, corresponding probably to similar features in the parent rock, the bedding probably representing original banding; for much of the ore has been deposited so as to replace metasomatically the pre-existing rock.

Dimensions of ore-bodies.

Some of the ore-bodies are of very large size. The largest, Garbham, is some 1,600 feet long, and 167 feet thick at its thickest section, 100 feet of this thickness being ore and the remainder lithomarge, wad, etc. From the commencement of work on this deposit in 1896 to the end of 1908, Garbham has yielded the enormous total of 600,889 tons of ore. The only other very large deposit in this district is Kodur; but this is really a series of scattered ore-bodies in lithomarge. It has yielded 306,170 tons of ore from 1892 to 1908. It was the first manganese-ore deposit to be worked in India.

Composition of ores.

The ores of the Vizagapatam district are composed mainly of psilomelane with subordinate amounts of pyrolusite, braunite, manganmagnetite, and in one case (Garividi) vredenburgite. They are usually second and third grade—although s me first-grade ore has been obtained at Kodur—and can be divided into manganese-ores (above 40 per cent. Mn) and ferruginous manganese-ores (below 40 per cent. Mn). They are characterised by high iron and phosphorus contents, and comparatively low silica (see table 64).

B.—The Gondite Group.

The gondite series.

The gondite series[1] is composed of metamorphosed manganiferous sediments of Dharwar age. and is haracterised by the presence of various

[1] *Mem. Geol. Surv. Ind.*, XXXVII, pp. 306—365.

manganiferous silicates, the most important of which are the manganese-garnet, spessartite, and the manganese-pyroxene, rhodonite. The garnet occurs commonly as a rock composed of spessartite and quartz, and this is the rock that has been called *gondite*, after the Gonds, one of the aboriginal races of the Central Provinces. Other common rocks are spessartite-rock, rhodonite-rock, and rhodonite-quartz-rock. The series is developed typically in the districts of Balaghat, Bhandara, Chhindwara, and Nagpur, in the Central Provinces, but has also been found in several other areas, namely:—Narukot State in Bombay, Jhabua in Central India, Gangpur State in Bengal, and probably in Banswara State in Rajputana. It probably exists also in the Seoni district, Central Provinces.

Forming an integral portion of the same masses of rock as the gonditic rocks, there are, at many places, large bodies of manganese-ore, often of large size and first-rate quality, some of the manganese-ore deposits of the Central Provinces being the most valuable in India, and second to none found in other parts of the world.

Origin.

The rocks of the gondite series are supposed to have been formed by the metamorphism of a series of sediments deposited during Dharwar times. These sediments were partly mechanical (sands and clay) and partly chemical (manganese oxides). When these sediments were metamorphosed, the sands and clays were converted into quartzites and mica-phyllites and mica-schists; the purest of the manganese-oxide sediments were compacted into crystalline manganese-ores; whilst mixtures of the mechanical sediments, sand or clay, with the chemical sediment, manganese oxide, were converted into rocks composed of manganese silicates—spessartite and rhodonite—any silica left over after accounting for the formation of these minerals appearing as quartz. The rocks thus formed constitute the *gondite series*. There is abundance of evidence to prove that the manganese-silicate-rocks of the gondite series have been subjected to extensive oxy-alteration, subsequent to their formation, but probably in Archæan times. As a result of this alteration large bodies of manganese-ore have been formed; no decisive evidence has yet been obtained indicating the relative proportions of the workable ores that are the result of the direct compression of the purer portions of the original manganese-oxide sediments, and that have been formed by the subsequent alteration of the rocks of the gondite series,

Nagpur-Balaghat area: mode of occurrence.

The ore-bodies thus formed occur as lenticular masses and bands intercalated in the quartzites, schists, and gneisses; and, as a result of its mode of origin, the ore is frequently found to pass, both laterally and along the strike, into the partly altered or quite fresh members of the gondite series, the commonest rock being gondite itself. The ore-bodies are often well-bedded parallel to the strike of the enclosing rocks, and several of them are often disposed along the same line of strike, indicating that they have probably all been produced from the same bed of manganiferous sediment. A good example of such a line of deposits is one in the Nagpur district, stretching from Dumri Kalan in an easterly direction as far as Khandala, a total distance of 12 miles, this line including the valuable deposits of Beldongri, Lohdongri, Kacharwahi, and Waregaon.

Dimensions of ore bodies.

The ore-bodies often attain great dimensions. The Balaghat deposit is 1¾ miles long; at Manegaon in the Nagpur district the ore-body is 1½ miles long; whilst the band running through Jamrapani, Thirori, and Ponia, in the Balaghat district, is exposed more or less continuously for nearly 6 miles. As examples of great breadth may be quoted Kandri, 100 feet thick of pure ore, and Ramdongri, with a combined thickness of 1,500 feet of ore and gonditic rocks. The depth to which these ore-bodies extend is unknown. It is, however, almost certain that, in many cases, they extend to at least 100 to 400 feet below the outcrop, *e.g.*, some of the deposits occupying hills in the Central Provinces; and it is very probable that some of the Central Provinces deposits extend to depths considerably greater than these: for the evidence obtained indicates that the deposits were formed in depth, so that the position of the deposit bears no genetic relation to that of the surface. An idea of the size of some of these deposits can be obtained from the amounts of ore they have yielded (for details of which see Chapter XXII of *Memoirs*, Vol. XXXVII). 300,000 tons of ore have been won from Balaghat in eight years, over 200,000 tons from Kandri in nine years, and between 100,000 and 200,000 tons from each of Mansar, Lohdongri, and Chikhla in the Central Provinces, and from Kajlidongri in Jhabua. The total production from deposits of the gonditic type was over 400,000 tons in 1906 (the Central Provinces and Jhabua), 500,000 tons in 1907 (the Central

Provinces and Jhabua), and 450,000 tons in 1908 (the Central Provinces, Jhabua, and Gangpur).

Composition of ores.

The typical ores of the Nagpur-Balaghat area of the Central Provinces consist of mixtures of braunite and psilomelane of different degrees of coarseness of grain. The most typical ore is a hard fine-grained ore composed of these two minerals. Other minerals found in the Central Provinces ores are hollandite, vredenburgite, sitaparite, and rarely pyrolusite. The ores exported from the Central Provinces are nearly all of first grade, although at times of high prices a small quantity of second-grade ore is exported. The chief characteristics of these ores are the high manganese contents (usually 50 to 55 per cent.), moderately high iron (usually 4 to 8 per cent.), rather high silica (usually about 4 to 8 per cent., and due to the braunite in the ore), and fairly low phosphorus (about 0·07 to 0·14). For analyses see table 64, page 148.

Ores in crystalline limestones.

In addition to the deposits found in association with spessartite- and rhodonite-bearing rocks in the Central Provinces, manganese-ores are sometimes found in association with crystalline limestones, usually containing piedmontite, and also of Dharwar age. Ores of this character are found characteristically in the Nagpur and Chhindwara districts. The manganese-ores occurs either as lines of nodules or as fairly definite beds in the limestone, the latter being the rarer mode of occurrence. In most cases it is not found profitable to work these ores; but where the bed of ore is of greater thickness than usual, as in the Junawani forest, it may pay at times of high prices; whilst patches of residual nodules accumulated during the dwindling of limestones will pay to work at any time, if not too far removed from transport facilities. The ores found thus are usually composed of braunite and psilomelane or hollandite. These ores, and the associated crystalline limestones and calcareous gneisses, are probably the products of the metamorphism of calcareous sediments with associated manganiferous ores, and are thus analogous in origin to the ores associated with the true gonditic rocks.

The remarks in the foregoing paragraphs apply particularly to the deposits found in the Central Provinces, but apply also in a general way to the deposits found associated with rocks of the gondite series in other parts of India. A few remarks about these are given below.

Gangpur, Bengal.

During 1908 the extension of the gondite series into western Bengal has been proved by the discovery of manganese-ore deposits in Gangpur State associated with rocks containing spessartite and rhodonite. The ores are typical gonditic ores, containing braunite in a matrix of psilomelane. Some 20,000 tons of ore were won at Gariajhor during 1908. In quality the ore is similar to that of the Central Provinces.

The following figures are summarised from analyses supplied by Mr. I. Shrager of cargoes shipped during 1909, the manganese and phosphorus figures representing eight analyses on a total of 3,600 tons of ore, and the other constituents four analyses on a total of 1,600 tons of ore :—

	Limits of analyses.	Mean of analyses.
Manganese	47·64 —54·13	50·53
Iron .	5·53 — 6·35	5·85
Silica .	2·6 — 8	5·7
Phosphorus	0·018— 0·143	0·089
Moisture .	0·78 — 1·16	0·96

Narukot, Bombay.

Rocks of the gondite series with associated manganese-ore have been found in a small hill at Jothvad in Narukot State, Bombay. The occurrence is of no economic importance, but of great scientific interest. The rock surrounding the hill is a porphyritic biotite-granite presumably of Archæan age, and apophyses from this pierce the gonditic rocks of the hill. Isolated pieces of gonditic rocks are included in the granite, and amongst these inclusions are pieces of manganese-ore, proving that a portion at least of the manganese-ore had been formed before the time of intrusion of the granite into the Dharwar rocks of the area.

Panch Mahals.

Manganese-ore deposits are being worked near Sivarajpur in the Panch Mahals. The rocks with which they are associated are Champaners, that

is, Dharwars; no rocks of gonditic nature have been found in this area, but it seems, judging from reports, that, although a portion of the ores has certainly been formed by the superficial replacement of quartzites, a portion may have been deposited contemporaneously with the enclosing Dharwar rocks; in this case the deposits may be classified with the gonditic deposits. The absence of gonditic rocks would then mean that the rocks—as at the Balaghat deposit in the Central Provinces—had not been subjected to such intense metamorphism as that which produced the gonditic rocks associated with most of the Central Provinces deposits. Over 50,000 tons of ore have been won from this area in the three years 1906 to 1908. The composition of the ore can be seen from table 64.

Jhabua, Central India.

The chief deposit in Jhabua State is that situated at Kajlidongri. This is a true gonditic occurrence, and the rocks associated with the manganese-bearing rocks are those known as Aravallis, which are in this part of India the equivalents of the Dharwars. In the six years 1903 to 1908 this deposit has yielded nearly 150,000 tons of manganese-ore. For the quality of the ore see table 64.

C.—The Lateritoid Group.

Lateritoid deposits.

In several parts of India manganese-ore deposits are found on the outcrops of rocks of Dharwar age, associated with the latter in such a manner as to leave little doubt that the ores have been formed by the replacement at the surface of Dharwar schists, phyllites, and quartzites. The masses of ore thus formed do not consist entirely of manganese-ore, but often contain considerable quantities of iron-ore; and every gradation is to be found from manganese-ores, through ferruginous manganese-ores and manganiferous iron-ores, to iron-ores. The masses of ore thus formed are often more or less cavernous and bear considerable resemblance to ordinary laterite. In fact some geologists would designate such occurrences by this term; but others would object: and, therefore, to obviate this difficulty the term *lateritoid*—meaning like laterite—has been introduced to designate this class of deposit. Lateritoid deposits are, then, irregular deposits of iron- and manganese-ores, occurring on the outcrops of Dharwar rocks, and resembling in their cavernous and

rugged aspect masses of ordinary laterite. When the rock replaced is a schist or phyllite, it is usually found altered to lithomarge below the capping of ores. The mineral composition of the ores thus formed is usually fairly simple. The manganese-ores are pyrolusite, psilomelane, wad, and more rarely pseudo-manganite, and manganite; whilst the iron-ores are limonite and earthy hematite. The harder crystalline minerals—braunite, vredenburgite, sitaparite, magnetite, and specular hematite—are found rarely or never in the lateritoid ores. Hollandite may sometimes occur. The chemical characteristics of the manganese-ores are high iron, low silica, and often very low phosphorus. The manganese is usually correspondingly low, so that the ores won consist mainly of second-grade manganese-ores and third-grade ferruginous manganese-ores. Such deposits can be worked to the greatest advantage when a market can be found for the iron-ores and manganiferous iron-ores, as well as for the manganese-ores.

Singhbhum and Jubbulpore.

The areas where ores of this nature have been found are given on page 160. Singhbhum and Jubbulpore have yielded small quantities of merchantable ore, but the most important of the lateritoid areas are Mysore and Sandur. A large number of deposits, many of them of large size, have been located in the Sandur Hills, mostly perched up on the edge of the hills at an average elevation of about 1,000 feet above the plains. When transport difficulties have been surmounted these deposits may be expected to yield large quantities of second-grade and third-grade ores, with possibly a certain proportion of first-grade ore from the Kamataru portion of the State. The deposits are being worked by the General Sandur Mining Company, Ltd. During the years 1905 to 1908 some 50,000 tons of ore have been won from these deposits, mainly from the Ramandrug and Kannevidalli areas. For analyses see table 64, page 148. The manganese-ore deposits of Mysore are numerous, but very few of them can compare in size with those of the Sandur Hills, although they have been formed in the same way. The chief exception is the Kumsi deposit in the Shimoga district, from which some 160,000 tons of ore have been won in the three years 1906 to 1908. The industry started in Mysore in 1906 and assumed a condition of great activity during 1906 and 1907. About 230,000 tons of ore have been won in the three

Sandur.

Mysore.

years 1906 to 1908. The chief companies operating in this State are the New Mysore Manganese Company, Ltd., recently taken over by the Workington Iron Company, Ltd., and operating in the Shimoga district; the Peninsula Minerals Company of Mysore, Ltd., operating in the Chitaldrug and Tumkur districts; and the Shimoga Manganese Company, Ltd., operating in the Kadur and Shimoga districts.

The Laterite Group.

Goa and Belgaum.

Manganese-ores are sometimes found in true laterite; but such ores are rarely of much economic value. The ores of Goa occur in part in this way (in low-level laterite), as also those of Belgaum (in high-level laterite). They are not economically of great importance, owing to the irregular manner in which they occur, and their extremely variable composition. Picked ores, however, are similar in composition to the picked lateritoid ores.

Mica.

Production.

The total and provincial production of mica in India during the five years 1904 to 1908 is shown in table 71. From this it will be seen that the production has risen from 22,164 cwts. in 1904 to 53,543 cwts. in 1908, the average annual production during the five years being 41,219¼ cwts., or 2,061 tons, which is nearly double the average figure—1,140 tons—for the previous five years.

From this table it will also be seen that more than half the Indian production (57·3 per cent.) is contributed by Bengal—the mica mines lying in the districts of Hazaribagh, Gaya, and Monghyr. Madras contributes 31·4 per cent., chiefly from the Nellore district, but a very small quantity has been won in the Nilgiris (60 cwts. in 1905). Ajmere and Merwara in Rajputana contribute the remaining 11·3 per cent. It is only during the present quinquennium that the mica-mining industry in Rajputana has assumed a position of importance.

TABLE 71.—*Provincial Production of Mica for the years 1904 to 1908.*

PROVINCE.	1904.	1905.	1906.	1907.	1908.	*Average.*
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
Bengal . . .	16,520	14,601	22,360	28,579	36,060	*23,624*
Madras . .	4,840	8,280	24,420	15,865	11,249	*12,931*
Rajputana .	804	2,760	5,763	7,759	6,234	*4,664*
TOTAL	22,164	25,641	52,543	52,203	53,543	*41,219*

Exports.

Table 72 shows the quantity and value of the mica exported during the years 1903-04 to 1907-08, the average quantity being 32,605 cwts., or 1,630 tons, of an average value of £5·07 per cwt. The average quantity during the period of the previous Review was 19,173 cwts., or 959 tons, worth an average of £4·05 per cwt.

Internal consumption.

Comparison of these figures with those for production shows that there was an average annual excess of production over exports of about 400 tons. It is probable that the reported figures of production are below the true ones; partly owing to under-statement to escape royalty, and partly due to mica stealing. This figure—400 tons—may, however, be taken as giving a rough idea of the internal consumption of mica in India: for a considerable quantity of mica of the poorer grades is used in India for ornamental and decorative purposes, and a small quantity of the larger sheets for painting pictures on.

Values.

There was an increase from £4·05 to £5·07 per cwt. in the value of the mica, and from £77,613 to £165,403 in the value of the average annual production of mica in the present quinquennium (1903-04 to 1907-08) as compared with the period of the previous Review (1897-98 to 1902-03). Table 73 shows the exports arranged according to province of export. The Bengal and Madras exports are of the mica produced within those provinces; and the Bombay exports consist, probably, of mica won in Rajputana. From these figures

it will be seen that the Bengal mica has the highest average value —£5·25 per cwt. (£4·26 for the period 1897-98 to 1902-03). Madras mica stands second—£4·69 per cwt. (£3·67 during the period of the previous Review); and Bombay mica third—£3·80 per cwt. (£3·30 for the period of the previous Review).

TABLE 72.—*Exports of Indian Mica during the years 1903-04 to 1907-08.*

Year.	Quantity.	Value.	Value per cwt.
	Cwts.	£	£
1903-04	21,548	86,297	4·15
1904-05	19,575	97,932	5·00
1905-06	31,554	159,627	5·05
1906-07	51,426	254,999	4·95
1907-08	38,922	228,161	5·86
Average	*32,605*	*165,403*	*5·07*

TABLE 73.—*Exports of Mica for the years 1903-04 to 1907-08.*

Year.	Bengal.			Bombay.			Madras.		
	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.	Weight	Value.	Value per cwt.
	Cwts.	£	£	Cwts.	£	£	Cwts.	£	£
1903-04	18,001	67,802	**3·76**	217	374	**1·72**	3,330	18,121	**5·44**
1904-05	13,167	59,187	**4·49**	74	132	**1·78**	6,334	38,613	**6·09**
1905-06	21,568	107,904	**5·00**	198	1,221	**6·16**	9,788	50,502	**5·16**
1906-07	35,496	191,812	**5·40**	634	2,384	**3·76**	15,296	60,802	**3·97**
1907-08	25,374	169,810	**6·69**	710	2,862	**4·03**	12,833 (*a*)	55,476 (*a*)	**4·32** (*a*)
Average	*22,721*	*119,303*	**5·25**	*366*	*1,394*	**3·80**	*9,516*	*44,703*	**4·69**

(*a*) Exclusive of 5 cwts., valued at £13, exported from Burma during 1907-08.

Table 74 shows the average distribution of exported mica during the period under review. The United Kingdom took the largest share, amounting to 61·9 per cent. of the average total value, but much of the mica sent to the United Kingdom is sold there for transmission to the Continent and America. The mica sent direct to America brought a higher price than that sent to other countries, because only the better qualities can stand the heavy import duty imposed by the Dingley Tariff in 1897.

Distribution of mica exported.

TABLE 74.—*Average Distribution of Indian Mica exported during the years 1903-04 to 1907-08.*

Exported to	Average Quantity.		Average Value.		Value per cwt
	Cwts.	*Per cent. of total.*	£	*Per cent. of total.*	£
United Kingdom . .	17,226	*52·8*	102,307	*61·9*	5·94
United States . . .	4,781	*14·7*	29,497	*17·8*	6·17
Germany	7,391	*22·7*	21,337	*12·9*	2·89
Belgium . . .	1,050	*3·2*	3,551	*2·1*	3·38
France	558	*1·7*	2,497	*1·5*	4·47
Other countries . . .	1,599	*4·9*	6,214	*3·8*	3·89
Average Total .	**32,605**	*100·0*	**165,403**	*100·0*	5·07

Over 90 per cent. of the world's output of mica is derived from India, Canada, and the United States. Of the minor mica producers Brazil is the most important. In table 75 are shown the values of the mica raised during the previous fifteen years in the three leading countries. From this it will be seen that in the quinquennium 1894 to 1898, India contributed 68·1 per cent. of the total: in the next quinquennium (1899 to 1903), owing to the increased output from

World's production.

Canada, the Indian contribution decreased to 60·1 per cent.; whilst during the third quinquennium (1904 to 1908), the Indian mica industry expanded enormously, but the proportion increased only to 61·8 per cent. owing to a great increase in the American production, and an abnormally large production by Canada (£116,209) in 1906. The figures given in table 75 are summarized in table 76, from which it will be seen that during the fifteen years India has contributed roughly three-fifths of the total and Canada and the United States roughly one-fifth each. The effects of the Dingley Tariff in America are considered in the previous Review (page 66).

TABLE 75.—*Value of Mica raised in the three Principal Producing Countries during the fifteen years 1894 to 1908.*

YEAR.	Canada.	India.	United States of America.	Total.	*India's per cent. of total.*
	£	£	£	£	
1894	9,116	42,516	9,415	61,047	*69·64*
1895	13,000	71,481	7,671	92,152	*77·57*
1896	12,000	76,891	9,223	98,114	*78·37*
1897	15,200	71,238	22,424	108,862	*65·44*
1898	23,675	53,890	26,414	103,979	*51·83*
TOTAL	**72,991**	**316,016**	**75,147**	**464,154**	..
Average	*14,598*	*63,203*	*15,030*	*92,831*	*68·08*
1899	32,600	73,372	25,576	131,548	*55·78*
1900	33,200	109,554	25,079	167,833	*65·28*
1901	32,000	70,034	23,716	125,750	*55·69*
1902	27,181	87,594	19,385	134,160	*65·29*
1903	35,571	86,297	28,626	150,494	*57·34*
TOTAL	**160,552**	**426,851**	**122,382**	**709,785**	..
Average	*32,110*	*85,370*	*24,477*	*141,957*	*60·14*
1904	30,584	97,932	24,063	152,579	*64·18*
1905	33,634	159,627	40,231	233,492	*68·37*
1906	116,209	254,999	54,998	426,206	*59·83*
1907	66,604	228,161	78,422	373,187	*61·11*
1908	38,320	126,834	53,585	218,739	*57·97*
TOTAL	**285,351**	**867,553**	**251,299**	**1,404,203**	..
Average	*57,070*	*173,511*	*50,260*	*280,841*	*61·78*

TABLE 76.—*World's Production of Mica* (*Summary of Table 75*).

PERIOD.	Canada.	India.	United States.	Total.
	£	£	£	£
1894—1898	72,991	316,016	75,147	**464,154**
1898—1903	160,552	426,851	122,382	**709,785**
1904—1908	285,351	867,553	251,299	**1,404,203**
TOTAL	**518,894**	**1,610,420**	**448,828**	**2,578,142**
Per cent. of total	*20·1*	*62·5*	*17·4*	*100·0*

Increased use of mica.

It will be noticed that, commencing with 1905, there has been a great increase in the world's annual production of mica. This is due largely to the invention of *micanite*, in which small and inexpensive sheets of mica are cemented together with shellac under pressure, with the production of large sheets costing much less than the natural sheets of equal size. The decreased cost of this material led to the increased application of mica in the arts, especially for electrical insulation. Furthermore, scrap mica, formerly thrown away, is now ground up and used for boiler and pipe lagging: as a lubricant, and for wall papers and paints.

Mining methods.

Since the last Review was issued an important contribution to our knowledge of the mica deposits in the Kodarma area has been made by Mr. A. A. C. Dickson,[1] who has made a practical modification of the system of mining suggested in the Memoir published by Geological Survey in 1902.[2] Mr. Dickson does not consider that overhand stoping, on account of the dangers incurred in the employment of a large number of untrained miners, can be universally followed in working out the mica-bearing pegmatite sheets and masses. He advocates and practises a system which he describes as 'transverse stoping with filling.' The pegmatite is followed to a depth of about 100 feet or more, and then, the dip being determined, an exploratory drift is run along the hanging wall of the sheet to fix its strike, which enables the construction of a main haulage way for the removal of the mica and associated waste minerals during the process of stoping out the material by a series of transverse

1 *Trans. Min and Geol. Inst. of India*, III. p. 57, (1908).

2 T. H. Holland, 'The Mica Deposits of India,' *Mem. Geol. Surv. Ind.*, XXXIV, part 2, p. 78.

cuts. Mr. Dickson has confirmed previous conclusions regarding the unnecessary cost of labour in carrying out the old system whereby in a mine, only 75 feet deep, over 200 workers are often required to deal with the material raised by ten miners at work below, and he has consequently given some practical suggestions for the introduction of simple machinery to deal with the water and disposal of waste materials. He agrees, therefore, that in the Kodarma area the day of the petty miner has passed, and the organisation of systematic mining with the help of machinery requires an expenditure of capital best obtainable by limited liabilities companies.

Labour statistics.

Most of the mica mines are under the control of the Indian Mines Act of 1901, so that the labour statistics for the period under review, given in table 77, afford a fair index of the activity of the industry. The average number of persons employed during the quinquennium was 15,667, so that roughly speaking the mica industry comes, with manganese, next to gold in providing labour. The risks attending mica mining seem to be somewhat less than those of coal mining in India.

TABLE 77.—*Labour Statistics of Mica Mines for the years 1904 to 1908.*

PROVINCE.	1904.	1905.	1906.	1907.	1908.	*Average.*
NUMBER OF PERSONS EMPLOYED—						
Bengal	6,927	6,122	7,716	10,683	10,287	*8,347*
Madras	6,585	9,199	8,007	7,154	4,661	*7,121*
Rajputana . . .	..	260	261	146	329	*199*
TOTAL	**13,512**	**15,581**	**15,984**	**17,983**	**15,277**	**15,667**
NUMBER OF DEATHS FROM ACCIDENTS AT MICA MINES—						
Bengal	10	2	8	12	3	*7·0*
Madras	2	2	2	..	..	*1·2*
Rajputana	..	..	..	1	..	*0·2*
TOTAL .	**12**	**4**	**10**	**13**	**3**	**8·4**
DEATH-RATE PER 1,000 PERSONS EMPLOYED AT MICA MINES—						
Bengal	1·44	0·32	1·04	1·12	0·29	*0·84*
Madras	0·30	0·21	0·25	..	..	*0·15*
Rajputana . . .	..	..	..	6·84	..	*1·37*
Average ..	*0·89*	*0·25*	*0·62*	*0·72*	*0·19*	*0·53*

NOTE.—These figures relate only to mines under the Indian Mines Act.

Petroleum.

Total production.

During the previous period reviewed the production of petroleum increased from 22¼ million gallons in 1898 to nearly 88 millions in 1903. During the past quinquennium the production has just been doubled, reaching the record output of 176,646,320 gallons in 1908. The increased production, as shown in table 78, has been due mainly to greater activity in Burma, and especially to the Yenangyaung field, where richer oil sands have been struck in the Twingon Reserve.

Position of India amongst oil-producing countries.

Nevertheless, India still occupies a comparatively low place among the oil-producing countries, and in 1907 turned out only 1·66 per cent, of the world's total supply. It will be seen by comparing table 79 with table 40 of the previous Review (page 71) that the order of the chief producing countries remains unaltered, India being sixth on the list, while America has increased its lead over the other countries by contributing over 63 per cent. of the world's output in 1907, when the total petroleum amounted to 36¾ million tons.

TABLE 78.—*Production of Petroleum during the years 1904 to 1908.*

YEAR.	QUANTITY.		VALUE.
	Gallons	*Metric tons.* (*a*)	
			£
1904	118,491,382	*475,869*	473,971
1905	144,798,444	*581,520*	604,203
1906	140,553,422	*564,470*	574,238
1907	152,045,677	*610,625*	610,015
1908	176,646,320	*709,423*	702,009

(*a*) The metric ton is assumed to be equivalent to 249 Imperial gallons of crude petroleum, most of which has an average specific gravity of about 0·885.

TABLE 79.—*World's Production of Petroleum in 1902 and 1907.*

COUNTRIES.	1902.		1907.	
	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*
United States . .	3,106,842,060	*47·94*	5,813,336,725	*63·34*
Russia . . .	2,818,901,575	*43·50*	2,164,775,690	*23·59*
Sumatra, Java, and Borneo . .	205,100,000	*3·17*	305,840,570	*3·33*
Galicia . . .	144,975,600	*2·24*	292,615,435	*3·19*
Roumania . .	72,097,550	*1·11*	284,137,245	*3·10*
India . . .	56,607,688	*0·87*	152,045,677	*1·66*
Japan . . .	41,755,000	*0·64*	70,372,365	*0·77*
Mexico . . .	..	..	35,000,000	*0·38*
Canada . . .	18,200,000	*0·28*	27,610,520	*0·30*
Germany . .	12,378,625	*0·20*	26,482,085	*0·29*
Peru . . .	2,100,000	*0·03*	2,291,660	*0·02*
Italy . . .	420,000	*0·20*	1,872,500	*0·02*
Other countries .	910,000		1,050,000	*0·01*
TOTAL	6,480,288,098	*100·00*	9,177,430,472	*100·00*

Imports of kerosene.

Foreign mineral oil has been to a certain extent displaced by the domestic products, but the consumption has greatly increased in India and there is thus still a large market in India and Burma for foreign oil, which has to pay an import duty of one anna a gallon.[1] The average annual imports of foreign mineral oils during the period 1897-98 to 1902-03 amounted to about 85½ million gallons, valued at 2⅓ million sterling, while for the five financial years 1903-04 to 1907-08 the average annual import dropped to a little over 73½ million gallons, valued at under 2 million sterling. The largest import occurred in 1901-02, when nearly 99 million gallons of foreign oil came into India, while the lowest figure was reached in 1905-06 with 61¼ million gallons. There was a rise again in the demand for foreign oil during the last calendar year, 1908, the imports amounting to 80¾ million gallons, partly due to a great increase in the quantity of oil brought from America, and a large importation of nearly 21 million gallons from the rapidly developing fields

[1] Increased in February 1910 to 1½ annas a gallon.

TABLE 80.—*Origin of Foreign Mineral Oil imported into India during the years 1903-04 to 1907-08.*

COUNTRIES.	1903-04.		1904-05.		1905-06.		1906-07.		1907-08.		*Average.*	
	Gallons.	*Per cent of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent of total*	Gallons	*Per cent. of total*	Gallons.	*Per cent. of total.*
Russia	57,321,149	71·2	40,309,782	48·2	7,766,838	12 7	2,248,965	3·6	9,417,523	11·8	23,412,851	31 8
United States	11,915,190	14 8	11,322,880	13·5	28,124,816	45·9	35,534,675	56 2	32,916,328	41·4	23,962,778	32·5
Other countries	11,285,595	14·0	31,998,505	38	25,314,890	41·4	25,403,262	40·2	37,240,489	46·8	26,248,548	35·7
TOTAL	80,521,934	100·0	83,631,167	100·0	61,206,544	100 0	63,186,902	100 0	79,574,340	100 0	73,624,177	100·0
Value	£ 2,299,252		£ 2,216,307		£ 1,489,525		£ 1,115,397		£ 2,100,392		£ 1,944,175	

of Roumania. The consumption of kerosene in India during 1908 exceeded 157 million gallons. During the five years 1898-99 to 1902-03, Russia gradually increased its predominance over America in supplying the oil imported into India. In 1898-99, Russia contributed 62·2 per cent. of the imports, and America 28·8 per cent.; in 1901-02 Russia contributed 85·5 per cent. and America only 9·5 per cent. During the period under review, however, the proportions have been reversed, the amount received from Russia in 1906-07 falling to 3·6 per cent. and from America rising to 56·2 per cent., with a slight reversal in 1907-08. The average annual proportion of the total contributed by these two countries has decreased from 93·5 per cent. during the period 1897-98 to 1902-03 to 64·3 per cent. during the period 1903-04 to 1907-08, due largely to the part Roumania now plays in supplying the Indian market (see table 80).

Value of imports.

The values of the imported mineral oil during the quinquennium are shown in table 81; the average annual value was £1,944,175 as compared with an average of £2,314,802 for the period of the previous review. The average value per gallon for Russian (6·28 to 6·45 pence) and American (7·22 to 7·41 pence) oils has risen slightly, and that for other oil imported has fallen considerably (7·17 to 5·24 pence).

Exports.

There is also a small annual export of Burmese oil and of paraffin wax (see table 82).

TABLE 81.—*Annual Value of Mineral Oil imported during the years 1903-04 to 1907-08.*

COUNTRIES.	1903-04.	1904-05.	1905-06.	1906-07.	1907-08.	Average.		Average value per gallon.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.		*Pence.*
Russia .	2,38,78,647	1,62,53,573	27,07,132	9,23,964	34,73,010	94,47,265	629,818	*6·45*
United States .	61,29,595	63,35,353	1,20,74,355	1,49,67,259	1,60,11,649	1,11,03,642	740,243	*7·41*
Other countries	44,80,544	1,06,55,676	75,61,382	83,39,737	1,20,21,222	86,11,712	574,114	*5·24*
TOTAL .	**3,44,88,786**	**3,32,44,602**	**2,23,42,869**	**2,42,30,960**	**3,15,05,881**	**2,91,62,619**	**1,944,175**	***6·33***

TABLE 82.—*Exports of Mineral Oil and Paraffin Wax during the years 1904 to 1908.*

YEAR.	Mineral oil.	Paraffin wax.
	Gallons.	Cwt.
1904	3,787,677	42,940
1905	2,422,589	63,966
1906	903,545	61,097
1907	1,764,075	76,075
1908	5,729,114	83,572
Average .	*2,921,400*	*65,530*

Occurrence of Indian petroleum.

The petroleum resources of India are confined to the two systems of folded rocks at either end of the Himalayan are :—

(1) The Iranian system on the west, including the Punjab and Baluchistan and continued beyond British limits to Persia, where the oil-fields have attracted interest for many years.

(2) The Arakan system on the east, including Assam and Burma, with their southern geotectonic extension to the highly productive oil-fields of Sumatra, Java, and Borneo.

In both areas the oil is associated with Tertiary strata, and has had, probably, similar conditions of origin in both cases, but the structural features of these areas are not equally suitable for the retention of oil in natural reservoirs. In Burma, however, the conditions have been locally ideal: the well-known Yenangyaung field lies in a N.N.W.—S.S.E. flat anticline, the axis of which by variation in pitch has produced a flat dome in the Kodaung tract. The rocks in this dome include several porous sands at various depths, each covered by an impervious clay-bed, which has helped to retain the oil until the impervious layers are pierced by artificial wells. In the Baluchistan area the rock-folds have been truncated by agents of denudation, or have been dislocated by earth-movements, and much of the original stores of oil have

disappeared. Oil-springs are common enough, but they are mere 'shows,' not connected with reservoirs that can be tapped by artificial means.

The provincial production of petroleum in India is shown in table 83.

Punjab and Baluchistan.

In the Punjab, oil-springs have been known for many years to exist in the Rawalpindi district and further to the south-west, but the total output of the Punjab (shown in table 83) is very small, ranging during the quinquennium between 400 and 1,700 gallons a year. For an account of the occurrence of oil in Baluchistan, reference should be made to the previous Review (page 74).

TABLE 83.—*Provincial Production of Petroleum during the years 1904 to 1908*

PROVINCE.	1904.	1905.	1906.	1907.	1908.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Burma	115,903,804	142,063,846	137,654,261	148,888,002	173,402,790
Assam	2,585,920	2,733,110	2,897,990	3,156,665	3,243,110
Punjab	1,658	1,488	871	1,010	420
TOTAL, Gallons	**118,491,382**	**144,798,444**	**140,553,122**	**152,045,677**	**176,646,320**
Total, Metric tons (a)	*475,869*	*581,520*	*564,470*	*610,625*	*709,423*

(a) The metric ton is assumed to be equivalent to 249 gallons of crude petroleum.

Assam.

Oil-springs are known in various parts of Assam, the most prominent being those at the southern foot of the Khasi and Jaintia hills, and those appearing in the coal-bearing series in North-East Assam, especially in the Lakhimpur district. The only marketable oil obtained comes from the Lakhimpur district, where systematic drilling has

been conducted during the past ten years by the Assam Oil Company, Ltd.

The first concession granted for oil prospecting in this area was obtained by Mr. Goodenough in 1867, the first boring being put down at Nahore-pung near Jaipur. After some unsuccessful operations (all by shallow hand-borings) near Jaipur, work was attempted on the Makum-pani, a small tributary of the Dehing river. Eight wells of only about 120 feet depth were drilled, and gave small quantities of oil. In 1882 the Assam Railways and Trading Company purchased the rights shared by Mr. Goodenough and Messrs. Killop, Stewart & Co., and made various unsuccessful attempts to exploit the oil in the Makum area. The Company's operations connected with timber extraction also led to the discovery of oil 'pungs' at Digboi, situated in the low hills crossing the railway line, about 8 miles from Margherita. Drilling was commenced at this locality in 1890 on a concession of 4 square miles leased to the Company for twenty-five years. In 1893 a Syndicate obtained a concession of 4 square miles adjoining that granted to the Railways and Trading Company, while in 1899 the Assam Oil Company, with a capital of £310,000, was floated to take over the oil-winning rights of both the Syndicate and the Railway Company, and the work of drilling for oil was thenceforth pushed on with greater vigour; but the Company has had to face unusual difficulties on account of the cost of labour in an unhealthy area, soft yielding strata to bore through, and imperfect exposures to guide the selection of sites. During the past five years, however, the footage drilled has amounted to 23,250, representing 11 wells, the deepest being 2,400 feet. The best results have been obtained from depths of about 1,400 to 1,700 feet. The total expenditure in drilling during the past five years has amounted to about £60,000.

The Digboi Field.

The village of Digboi is connected by the line of the Assam Railways and Trading Company with Dibrugarh on the Brahmaputra river, a distance of 54 miles. The Brahmaputra thus forms a channel for the distribution of the products to stations below, while a certain amount of the products are distributed by the Assam Bengal Railway, which joins the Dibrugarh line at Tinsukia, a distance of 20 miles from Digboi. To the north, east and west of Digboi there are flourishing tea-gardens, which also take some of the products of the refinery.

The population of Digboi numbers about 4,500 souls, all dependent on the oil industry and their small patches of cultivation on the land which has been cleared of the thick jungle that still covers the country around. The place is still highly malarious, the labour is almost all imported from India at expensive rates and the working expenses of the Company are thus increased in a way unknown in the productive fields of Burma. The country being covered with an impenetrable jungle and a heavy mantle of decomposition products, it is difficult to establish the geological structure of the area with sufficient precision to assist materially in the location of the oil-wells. The strata are highly inclined (always dipping at angles above 50°) and any errors in selecting the sites of new wells result in serious additional expenses in drilling.

There is no certainty that the oil is held by an anticlinal fold, for the only determinable dips in the area being drilled are all in one direction—to the S.S.E. or S.E.; but to the north and north-westwards of the wells the country is thickly jungle-clad and the rocks are covered with alluvium, which extends as a flat plain to the banks of the Brahmaputra. The outcrops of sandstone are often seen in freshly-made cuttings to be clogged with brown wax, and as the crude oil obtained in the deep wells is always highly charged with paraffin, it is probable that the oil on approaching the cooler surface, where the lighter hydrocarbons can escape, becomes solidified, thus preventing the free escape of further material. It is probable that this deposition of wax in the superficial parts of the sandstones accounts for the storage of crude oil in this area, without the aid of the anticlinal folds of alternating impervious shales and oil-bearing porous sands.

The output of crude oil in the Digboi field for the past ten years has been as follows :—

1899	623,372	gallons.
1900	753,049	,,
1901	631,571	,,
1902	1,756,759	,,
1903	2,528,785	,,
1904	2,585,920	,,
1905	2,733,110	,,
1906	2,897,990	,,
1907	3,156,665	,,
1908	3,243,110	,,

The principal products marketed are petrol, jute-batching oil, lubricating oils, paraffin wax, and a comparatively low grade of kerosene suitable for bazar consumption. The paraffin wax, sold as such or in the form of candles, appears to be of excellent quality with a melting point of 135° F. and over. Table 84 shows the amounts of the various products turned out during the past five years.

It will be noticed from this table that there has been a marked increase in the quantity of "batching" oil manufactured, there being a growing demand for this material in Eastern Bengal. The "batching" and lubricating oils turned out during the year 1908 formed 12·7 per cent. of the crude employed. The proportion of petrol has also been increased from 0·44 per cent. of the products in 1904 to 2·14 per cent. in 1908. The output of candles and wax is fairly steady, forming on an average 6·17 per cent. of the total products, while the kerosene manufactured amounted on an average to just under 49 per cent. of the total. About one-quarter of the crude oil is burnt in the works as fuel.

TABLE 84.—*Output of the Digboi Oil Refineries in the years 1904 to 1908.*

	1904.	1905.	1906.	1907.	1908.
Kerosene (*a*) . .	1,445,046	1,033,558	1,598,450	1,481,625	1,513,566
Batching oil (*a*) . .	15,978	49,203	260,644	285,006	406,868
Petrol (*a*) . . .	13,844	20,880	22,425	48,309	68,493
Wax (and candles) (*b*) .	1,370,067	1,297,088	1,603,063	1,636,872	1,683,072
Sundry oils (*a*) . .	93,438	91,333	112,303	132,590	137,167
Fuel oil (*a*) . .	..	782,300	707,044	897,283	785,207

(*a*) Imperial gallons. | (*b*) Lbs.

The whole of the sulphuric acid, caustic soda, ammonia and tin-plate required for the refinery is imported. The sulphuric acid used during the five years amounted to 834 tons, costing about £20 a ton delivered at the refinery.

The labour statistics are given in table 85.

TABLE 85.—*Average number of workers employed daily on the Digboi Oilfield during the years 1904 to 1908.*[1]

——	1904.	1905.	1906.	1907.	1908.
Men	341	466	572	510	493
Women	103	108	126	155	126
Children	24	37	55	50	30
TOTAL	468	611	753	715	649

The most productive oilfields of Burma are those on the eastern side of the Arakan Yoma, in the Irrawaddy valley, forming a belt stretching from the Magwe district, in which the well-known field of Yenangyaung occurs, through Myingyan, in which Singu occurs, across the Irrawaddy into Pakôkku, where Yenangyat is situated. The production of the Burmese oilfields for the years 1904 to 1908 is shown in table 86. Yenangyaung,[2] the oldest and best known of the fields, still holds an easy lead as a producer, and has undergone excessive development recently, owing to the advent of rival companies. Of the total $1\frac{1}{2}$ square miles of petroliferous territory, all that outside the two native 'reserves' of Twingon and Beme, is held under lease by the Burma Oil Company, the pioneers of this field. It is within the two small reserved tracts covering jointly some 450 acres, and especially within the Twingon Reserve that competition has been so keen as to threaten injury to the oil-sands by water liberated from water-sands, and danger of fire in the midst of a congested forest of greasy wooden derricks covering highly productive flowing wells emitting immense quantities of inflammable gas. In the Twingon area, besides the Burma Oil Company, three other companies have been actually at work and others intend to commence

Burma.

Yenangyaung.

1 The figures in this table show the numbers regularly employed in the refinery and on the field; but for buildings and similar works, outside contractors are employed and provide their own labour requirements, which may amount to about an average of 100 workers daily.

2 We are indebted to Mr. E. H. Pascoe for the following account of petroleum in Burma.

operations as soon as possible. The great increase in output for 1908 is a result of this competition. Such excessive exploitation is bound to be followed by premature exhaustion, and our next quinquennial report will have to record a decline, unless Khodaung and other extra-reserve areas are attacked with sufficient energy to compensate for the deficiency. The native industry will soon be a thing of the past, most of the grants having been sold or otherwise disposed of to the various companies in the field.

TABLE 86.—*Production of the Burma Oilfields during the years 1904 to 1908.*

OILFIELD AND DISTRICT.	1904.	1905.	1906.	1907.	1908.	Average.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	*Gallons.*
Akyab . .	47,082	53,455	35,423	28,877	35,667	*40,101*
Kyaukphyu . .	89,827	60,647	53,420	49,587	46,372	*59,972*
Yenangyaung, Magwe.	73,428,960	85,648,749	89,549,252	96,857,519	123,798,630	*93,856,622*
Singu, Myingyan .	23,677,450	37,541,177	34,843,621	43,543,566	43,048,948	*36,530,953*
Yenangyat, Pakôkku.	18,660,485	18,759,818	13,172,136	8,407,825	6,472,545	*13,094,562*
Thayetmyo . .	..	..	400	628	628	*552(a)*
TOTAL-Gallons .	115,903,804	142,063,846	137,654,261	148,888,002	173,402,790	*143,582,541*
Total Metric Tons.	*465,477*	*570,537*	*552,828*	*597,944*	*696,396*	*576,636*

(a) Three years only.

Yenangyat.

The output of the Yenangyat field, which was never a very rich one, is still declining in spite of the fact that a new portion—the Sabe area—has, chiefly on the recommendation of the Geological Survey of India, been recently opened up. The oil from the Sabe field proved at first to be what is known in America as 'roily,' spouting in the form of an emulsion with water. Clear oil has however now been obtained, and some satisfactory wells met with. This new field is not likely to be remarkable for productiveness or longevity, but will be found useful as soon as attention is withdrawn from the Twingon area.

Singu.

Although inferior to Yenangyaung, Singu is a promising field, and has up to the present been treated more or less as a reserve. It is now

being steadily and scientifically developed by the Burma Oil Company.

Other fields.

Among other areas in the Irrawaddy basin offering inducements to operators, the following have been tested, but so far with disappointing results: Minbu, Padaukpin and Bambyin (Thayetmyo), Prome, Tetma and Payagyigon-Ngashandaung (Gwegyo Hills, Myingyan), Sattein and Kyatti (Myingyan), and Chindwin.

Arakan coast.

Besides the Upper Burma oilfields, the islands off the Arakan coast, noted for their mud volcanoes, have also been known for many years to contain oil deposits of uncertain value. The chief operations have been carried on in the Eastern Barongo Island near Akyab and on Ramri Island in the Kyaukphyu district. Flooding and denudation in these regions have been too severe to warrant the expectation of oil in much quantity. The output from the Kyaukphyu wells has steadily declined and the average for the past five years is 40,261 gallons less than the average for the six years 1898 to 1903. In the case of Akyab, the decline in this average is only 2,825 gallons.

Transport.

A considerable length of the Burma Oil Company's 4-inch pipeline connecting Singu with Yenangyaung has been replaced by 6-inch and 8-inch pipes, and this improvement is still in progress. The 10-inch pipe-line connecting Yenangyaung with Rangoon, a distance of 275½ miles, has been completed and is now working. The three principal oilfields of Burma are therefore directly connected with Rangoon by pipe-line, and unless any difficulty is experienced with the latter, a continuous supply of oil is ensured.

Ruby, Sapphire, and Spinel.

Production.

During the period covered by the previous review, the whole of the output of these stones in the Indian Empire was derived from Upper Burma. But during the years 1906 to 1908 the sapphire deposits of Kashmir were again worked, with results at first fairly satisfactory, but so poor in 1908 as to offer no incentive for further work. Table 87 shows the annual output figures for Burma and Kashmir during the quinquennium, the average annual value being £84,406.

TABLE 87.—*Production of Ruby, Sapphire, and Spinel during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.		Average.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Carats.	£	Carats.	£	Carats.	£	Carats.	£	Carats.	£	Carats.	£.
Burma (*a*)	265,901	*90,612*	266,584	*88,340*	326.855	*95,540*	334.535	*95,114*	211.194	*47,921*	281,014	*83,505*
Kashmir	..	..	..	..	2.837	*1,327*	305,682	*3,144*	144.850	*33*	151,123	*1,501*
TOTAL, Carats and £	**265,901**	*90,612*	**266,584**	*88,340*	**329,692**	*96.867*	**640,217**	*98.258*	**356,044**	*47.954*	**371,687**	*84,406*

(*a*) The Burmese figures apply only to the work carried on by the Burma Ruby Mines. Ltd., and do not include the stones won by natives working under licenses from the company. They refer to the year ending February 28th covered by the annual reports of the company.

Burma.

The prosperous condition noticed in the previous review of the ruby-mining industry as conducted by the Burma Ruby Mines, Ltd., in the Mogok area, continued during the period under review until towards the end of 1907, when the demand for rubies suddenly fell away and prices declined, owing to the world-wide commercial depression that then set in. The slump continued during 1908, so that the output of stones was curtailed considerably, the value of the production, which was £95,114 in 1907, falling to £47,921. The effects of the commercial depression have probably been accentuated by the successful manufacture on a commercial scale of artificial stones. The average annual value of the stones won during the five years was £83,505, as compared with £89,345, the average figure for the period of the previous review (1898 to 1903). A small proportion of the value of the output is due to sapphires and spinels, the amount of which is indicated by the following figures for the company's years ending 28th February 1907 and 1909:—

	1906-07.	1908-09.
	£	£
Rubies	93,023	43,072
Sapphires	1,132	536
Spinels	1,385	434
	95,540	44,042

On account of the slump the company was unable to declare a dividend for the year ending 28th February 1909, for the second time since 1898, when the company first entered the dividend-paying stage. This depression is also reflected in the royalties derived by the company from the issue of licenses to native miners. These are shown below:—

Year.	£
1904	17,441
1905	12,129
1906	17,013
1907	19,849
1908	8,051

The Burma Ruby Mines, Ltd., was granted a new lease for 28 years with effect from the 30th April 1904, for the collection of precious stones in the townships of Mogok, Kyatpyin and Katha in the Ruby Mines District. The company is required by the lease to pay an annual rent of Rs. 2,00,000 (£13,333), *plus* 30 per cent. of the net profits made each year, this being a continuance of the arrangement previously in force.

Labour.

The following are the labour statistics for the ruby mines under the Mines Act:—

YEAR.	Average number of persons employed daily.
1904	1,553
1905	1,793
1906	2,367
1907	2,188
1908	1,140

The number of deaths during the period was 15, giving an average death-rate of 1·66 per 1,000. In addition large numbers of persons are engaged in working on their own account under licenses issued by the Burma Ruby Mines, Ltd. Thus in the year ending February 28th, 1907, the company issued 3,866 licenses covering 13,639 men at Rs. 20 each.

Rubies are also known to occur at Naniazeik in the Myitkyina district near the jadeite tract;[1] but the fees derived from licenses to work in this area have been very small—varying from Rs. 50 in 1904 to Rs. 440 in 1906, and no output has been reported. Licenses have also been granted for rubies in the Sagyin Hills, Mandalay district, and in the Shwebo district, but no favourable results seem to have been obtained.

Kashmir.

The sapphires of Kashmir seem to have been first discovered in 1881 or early in 1882, when a landslip disclosed the sapphire-bearing rocks. The actual locality is a valley near Soomjam in Padar, Zanskar, at

[1] *Rec. Geol. Surv. Ind.*, XXXVI, p. 161, (1907).

an elevation of about 13,500 feet; here the gem has been found both *in situ* in a felspathic igneous rock in a cliff 1,600 feet above the valley, and in the débris in the valley itself. For some years the Kashmir Darbar derived a considerable revenue from the sapphire mines, which were then left unworked for some years on the supposition that they had become exhausted. But in 1906 the Kashmir Mineral Company, Ltd., started work under license from the Darbar, and has obtained a considerable return of valuable stones. One stone obtained in 1907 was sold for £2,000. The very small value of the 1908 output is due to the very inferior quality of this year's production ('rock-sapphire'), Rs. 500 being the actual price obtained in Jammu for the whole output. Owing to the high altitude of the sapphire locality, the ground is under snow and inaccessible for the greater part of the year, work being possible during the months of July, August, and September only. Work has again been abandoned.

Salt.

Production.

The average annual production of salt in India during the five years 1904 to 1909 was 1,167,785 statute tons (see table 88), exclusive of that manufactured at Aden, which averaged 81,996 tons per annum during the same period. During the last year of the quinquennial period there was an increased output, as well as an increased import of foreign salt, to meet the greater demand which followed the last reduction of the salt tax. The salt manufactured in the country and imported by sea amounted to $1\frac{3}{4}$ million tons in 1908. The consumption thus amounted in this year to about $13\frac{1}{2}$ lbs. per head of the population.

TABLE 88.—*Production of Salt in India (excluding Aden).*

YEAR.	Statute Tons.	Metric Tons.
1904	1,105,051	*1,122,731*
1905	1,193,410	*1,212,504*
1906	1,157,745	*1,176,269*
1907	1,102,783	*1,120,427*
1908	1,279,937	*1,300,416*
Average	*1,167,785*	*1,186,469*

Sources of Indian salt.

The salt produced in India is obtained from three principal sources as before, but there has been a heavier output of sea-salt and a corresponding depression of the share contributed by the other sources. The proportions are as follows for 1904-08 :—

(1) Sea-water, from which 64·5 per cent. of the total production was obtained;

(2) Sub-soil water and lakes in areas of internal drainage, giving 25·2 per cent.; and

(3) Rock-salt beds, from which there was no increased production and consequently a slightly lower proportionate contribution to the increased total, namely, 10·3 per cent.

Provincial production.

Table 89 shows the provincial production for the five years 1904 to 1908.

TABLE 89.—*Provincial Production of Salt during the years 1904 to 1908.*

PROVINCE.	1904.	1905.	1906.	1907.	1908.	*Average.*
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	*Statute Tons.*
Aden .	66,007	97,727	67,535	90,385	88,324	*81,996*
Bengal .	88	3	61	26	48	*45*
Bombay.	430,409	425,090	390,535	385,441	454,991	*417,293*
Burma .	21,387	23,132	29,847	30,022	31,336	*27,145*
Gwalior State .	374	84	249	189	437	*267*
Madras .	356,834	388,646	412,717	353,271	435,120	*389,317*
Northern India .	282,421	342,190	312,559	320,689	341,694	*319,911*
Sind .	13,540	14,265	11,777	13,145	16,311	*13,807*
TOTAL, Statute Tons .	**1,171,060**	**1,291,137**	**1,225,280**	**1,193,168**	**1,368,261**	**1,249,781**
Total, Metric Tons .	***1,188,900***	***1,311,856***	***1,244,939***	***1,212,258***	***1,390,153***	***1,269,777***

The returns for provincial production show a marked increase in the amount of salt manufactured at Aden, from 54,428 tons, the average for the years 1898 to 1903, to 81,996 tons a year in the quinquennial period 1904-1908. There was also an increase in Bombay from an average of 357,507 tons to 417,293 tons per annum; in Burma from 21,664 to 27,145 tons; in Madras from 297,666 to 389,317 tons; in the North Indian lakes and mines from 290,535 to 319,911 tons; and in Sind from 11,695 to 13,807 tons per annum. The small quantities manufactured in Gwalior, 267 tons, and that separated in the manufacture of saltpetre in Bengal; 45 tons, are unimportant. The average annual total of salt production has thus risen from 1,038,000 tons for 1898-1903 to 1,249,781 tons for 1904-08.

Bombay, as before, is the chief producer, most of the salt being obtained from sea-water, supplemented by the use of sub-soil brine on the border of the Rann of Cutch in an area where possibly the brines are directly derived from sea-water. In the Madras Presidency, small quantities of salt are collected in the Masulipatam area, but the rest is manufactured from sea-water. In Upper Burma, salt is obtained from sub-soil brines in the districts of Sagaing, Shwebo, Myingyan, Yamethin, Lower Chindwin, Minbu, Meiktila, and the Hsipaw State. It is often difficult in some of the districts in the 'dry zone' of Upper Burma to obtain deep well water that is not noticeably saline.

Brine wells of Bawgyo.

A special account of the brine wells being worked near Bawgyo in the Hsipaw State has been published by Mr. T. D. LaTouche.[1] The only well now being worked is 45 feet deep, and in December 1905 the crude brine included 25·58 per cent. of dissolved salts, which are composed of about 60 per cent. of sodium chloride, 36 per cent. of the sulphate, with small quantities of other salts.

Sub-soil and lake-brine.

The most important of the areas worked for sub-soil and lake-brine is the desert region of Rajputana, from which nearly 300,000 tons of salt are manufactured every year. The whole country is impregnated with salt from the Coast of Cutch and Sind north and north-eastwards to the borders of Delhi district and Bhawalpur State. In many areas of internal drainage there are

[1] *Rec. Geol. Surv. Ind.* XXXV, p. 97, (1907).

small temporary salt-lakes, which are utilised, as at Sambhar and Didwana; while in other places sub-soil brine is raised, as at Pachbadra. Most of the salt in this region appears to be brought in as fine dust by the strong winds which blow from the south-west and south-south-west during the hot weather. These winds blow across the salt-incrusted Rann of Cutch, and carry away the finely-powdered salt in large quantities into the heart of Rajputana, where it becomes fixed when the following monsoon brings rain enough to wash the salt into the small lakes in areas of internal drainage.[1]

Sambhar Lake.

Sambhar, the largest of the Rajputana salt-lakes, covers an area of 60-70 square miles during the monsoon, but dwindles, generally, to a small central puddle by the following March or April. It has been shown by careful sampling at regular intervals that the mud forming the bed of the lake contains on an average 5·21 per cent. of sodium chloride down to a depth of at least 12 feet, and the amount stored in these higher layers of salt cannot thus be less than about 54 million tons. Since the lake was taken over by Government in 1870-71, about 4½ million tons of salt have been removed and sold away from Sambhar. During the past five years the average annual production amounted to 166,518 tons, most of which went to the United Provinces.

Distribution of Sambhar salt.

Table 90 shows the average annual distribution of Sambhar salt for the five years 1903-04 to 1907-08. From this table it will be noticed that Sambhar has been able to increase its slender hold on the Central Provinces and Behar in spite of the influx of foreign salt. In the case of the Central Provinces, the average annual amount supplied rose from 716 tons in 1897—1902 to 1,586 tons in the five financial years ending with 1907-08, while for the corresponding periods in Behar the rise was from 175 to the still small quantity of 371 tons.

Distribution of Pachbadra salt.

The average annual despatch of salt from Pachbadra during the years 1903-04 to 1907-08 amounted to only 20,558 tons, against 33,677 tons in the years 1897-98 to 1902-03. Of this amount, 8,287 tons, or 40 per

[1] T. H. Holland and W. A. K. Christie, *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 154-186. (1909).

cent., remained in Rajputana; 6,244 tons, or 30 per cent., going to Central India; 3,904 tons, or 19 per cent., going to the Central Provinces, and 2,098 tons, or 10 per cent., being sent to the United Provinces. There were thus great changes in the distribution of Pachbadra salt, for during the previous period reviewed the largest fraction (45 per cent.) went to the United Provinces, and only about 27 per cent. remained in Rajputana.

TABLE 90.—*Average annual distribution of Sambhar Salt.*

	1897-98 to 1902-03.		1903-04 to 1907-08.	
	Quantity.	Per cent.	Quantity.	Per cent.
	Tons.		Tons.	
United Provinces	91.443	*68·4*	114.711	*68·9*
Rajputana	20,371	*15·4*	23,490	*14·1*
Central India	11,713	*8·8*	16.058	*9·6*
Punjab and North-West Frontier Province	9,109	*6·8*	10.302	*6·2*
Central Provinces	716	*0·5*	1,586	*1·0*
Behar	175	*0·1*	371	*0·2*
Average Total	**133,527**	*100·0*	**166,518**	*100·0*

Production of rock-salt.

There has been an increase in the average annual output of rock-salt from 109,540 tons in the period 1898—1903 to 120,439 tons per annum in 1904—08; but, on account of the heavier output from other sources, especially sea-water, the rock-salt makes a smaller proportion of the total, being only 10·3 instead of 11·2 per cent. of the total production of India, excluding Aden. The details are shown in table 91, from which it will be seen that the increase in production of rock-salt is due to the mines on the Salt Range, which gave an average annual output of 100,839 tons in 1904—08, against 89,023

tons in the preceding period. The changes in Kohat and Mandi State are less than the annual variations.

A general account of the occurrences of rock-salt in the Punjab and North-West Frontier Province will be found in the previous Review (pp. 83, 84) and in the Sketch of the Mineral Resources of India, 1908, pp. 56-58.

TABLE 91.—*Production of Rock-Salt during the period 1904—1908 compared with the period 1898—1903.*

YEAR.	Salt Range, Punjab.	Kohat, North-West Frontier.	Mandi State.	TOTAL.	Percentage of total salt production of India.
	Statute Tons.	Statute Tons.	Statute Tons.	**Statute Tons.**	
1904	107,403	16,664	4,507	**128,574**	11·6
1905	94,048	14,897	3,571	**112,516**	9·4
1906	107,194	13,436	3,609	**124,239**	10·7
1907	101,779	17,228	4,085	**123,092**	11·2
1908	93,774	16,049	3,954	**113,777**	8·9
Average for 1904—1908	**100,839**	**15,655**	**3,945**	**120,439**	**10·3**
Per cent. of average total (1904—1908).	83·7	13·0	3·3	100·0	..
Average for 1898—1903	*89,023*	*15,842*	*4,675*	*109,540*	*11·2*
Per cent. of average total for 1898—1903.	81·2	14·5	4·3	..	...

Imports and origin of foreign salt.

There was a larger increase of foreign salt during the past five years than during the previous period reviewed, the principal increase being during the last three years. The principal feature of interest is the importation from Spain, which reached the large quantity of 85,966 tons in the financial year 1907-08 and to 103,479 tons in the calendar year 1908. The demand from the United Kingdom has been falling at the same time, the share of the average annual total dropping from 56 to 45 per cent., while for the calendar year 1908 the salt imported from the United Kingdom was under 35 per cent. of the total (see table 92).

Most of the salt imported is landed at Calcutta, the next larger importer being the Province of Burma which, however, only takes between about 50,000 and 60,000 tons a year.

TABLE 92.—*Imports of Salt during 1903-04 to 1907-08 compared with the period 1897-98 to 1902-03.*

IMPORTED FROM	1897-98 to 1902-03.		1903-04 to 1907-08.	
	Quantity.	*Per cent. of total.*	Quantity.	*Per cent. of total.*
	Tons.		Tons.	
United Kingdom	243,216	*56·1*	219,347	*45·2*
Germany	56,928	*13·1*	67,824	*14·0*
Aden	49,350	*11·4*	69,903	*14·4*
Arabia	42,887	*9·9*	60,338	*12·4*
Egypt	28,377	*6·5*	26,901	*5·6*
Spain	..	..	35,744	*7·4*
Persia	12,441	*2·9*	1,758	*0·4*
Other countries	555	*0·1*	3,125	*0·6*
Average Annual Total	**433,754**	*100·0*	**484,940**	*100·0*

Saltpetre.

Conditions essential for the formation of saltpetre.

For the formation of saltpetre in a soil the necessary conditions are (1) supplies of nitrogenous organic matter, (2) climatic conditions favourable to the growth and action of Winogradsky's so-called nitroso and nitro bacteria, converting urea and ammonia successively into nitrous and nitric acids, (3) the presence of potash, and (4) meteorological conditions suitable for the efflorescence of the potassium nitrate at the surface. An ideal combination of these necessary circumstances has made the Behar section of the Gangetic plain famous for its production of saltpetre.

In this part of India we have a population of over 500 per square mile, mainly agricultural in occupation, and thus accompanied by a high proportion of domestic animals, supplying an abundance of organic nitrogen. With a mean temperature of 78° F., confined to an annual range of 68°, and for a large part of the year when the air has a humidity of over 80 per cent., with a diurnal range not exceeding 8° above or below 84° F., the conditions are unusually favourable for the growth of the so-called 'nitrifying' bacteria.

With a population largely using wood and cow-dung for fuel, the soil around villages naturally would be well stocked with potash, and finally, with a period of continuous surface desiccation following a small rainfall, the sub-soil water, brought to the surface by capillary action in the soil, leaves an efflorescence of salts, in which, not surprisingly, potassium nitrate is conspicuous. Under these conditions Behar has for many years yielded some 20,000 tons of saltpetre a year.

System of manufacture.

The system of manufacture has been very frequently described in detail,[1] and consists essentially in dissolving out the mixed salts contained in soil around villages, and effecting a first rough separation of the two most prominent salts—sodium chloride and potassium nitrate—by fractional crystallisation. The impure sodium chloride is consumed locally, whilst the saltpetre is sent to refineries for further purification before export.

Production and export.

The returns for production are so manifestly imperfect, being considerably below the amounts of export, that the export figures must be taken as the only index, though still an imperfect one, to the extent of the manufacture. The export figures for the past five years are given in table 93, showing an average annual export of 358,989 cwts., valued at £265,135.

Variations in exports.

There is no definite directional change indicated by these figures, but a comparison with the returns for the past twenty-five years shows that there has been only a small reduction in the amount of exported saltpetre,

[1] G. Watt. Dictionary of the Economic Products of India, Vol. VI, part II, s. 686, p. 433, and literature quoted. Also D. Hooper, *Agricultural Ledger*. 1905, No. 3, giving many analyses.

in spite of the constantly increasing production in other parts of the world of nitrates, both derived from natural deposits and artificially manufactured; and of wholesale changes in the substances used for manures and for the manufacture of explosives. For the six years 1878—1883 the average quantity of saltpetre exported amounted to 405,568 cwts. a year; for a similar period ten years later, namely, 1888 to 1893, the average annual exports were 389,989 cwts; whilst for the period 1897-98 to 1902-03 the average annual exports were 382,353 cwts., valued at £262,592. The highest values, ranging from about £600,000 to nearly £900,000 a year, occurred at the time of the American Civil War from 1860 to 1864, but saltpetre was then an essential constituent of explosives and India had almost a monopoly of supplies.

TABLE 93.—*Total Exports of Saltpetre by Sea and Land during the years 1903-04 to 1907-08.*

YEAR.	QUANTITY.		Value.	Value per cwt.
	Cwts.	*Metric tons.*		
			£	Shillings.
1903-04	392.160	*19.922*	271,725	13·85
1904-05	348,715	*17,716*	241,592	13·85
1905-06	336,464	*17,093*	256,889	15·27
1906-07	353,471	*17.956*	276.247	15·63
1907-08	364,104	*18,496*	279,221	15·33
Average	*358,989*	*18,236*	*265,135*	*14·77*

Distribution of exported saltpetre.

As in the period covered by the previous Review, the percentage of the total exports taken by the three leading consumers, United States, United Kingdom, and Hongkong, has remained at about 80 per cent., but the United States has risen from third to first place (from 24·0 to 32·8 per cent.), the United Kingdom has sunk to second place (from 30·7 to 25·0

per cent.), and Hongkong to third place (from 25·7 to 22·1 per cent.). The distribution figures are shown in table 94.

TABLE 94.—*Average Distribution of Saltpetre exported by Sea during the years 1903-04 to 1907-08.*

EXPORTED TO	Average annual quantity.	*Per cent. of average total.*
	Cwts.	
United States	117,784	*32·8*
United Kingdom	89,604	*25·0*
Hongkong	79,435	*22·1*
Mauritius	22,756	*6·3*
France	21,716	*6·1*
Straits Settlements	10,075	*2·8*
Ceylon	10,029	*2·8*
Other countries	7,524	*2·1*
Average Total for the years 1903-04 to 1907-08	**358,923**	*100·0*

Provincial shares in the exports.

Calcutta is still, as it always has been, the chief port through which saltpetre leaves India, the exports during the period under review having amounted to 98·6 per cent. of the total, as compared with 98·5 per cent. during the previous period. Of the small remaining amount exported, 1·1 per cent. left *viâ* Karachi. The average annual exports from the different provinces have been as follows during the years 1903-04 to 1907-08:—

	Cwts.
Bengal	353,902
Sind	4,005
Bombay	1,006
Madras	10
TOTAL	**358,923**

The Calcutta supply is obtained mainly from Behar, as shown in table 95, which has been compiled from returns published each year by the Commissioner of Northern India Salt Revenue.

TABLE 95.—*Average Annual Imports of Saltpetre into Calcutta for the years 1903-04 to 1907-08.*

OBTAINED FROM	Average annual quantity.	*Per cent. of average total.*
	Cwts	
Behar	212,870	*56·1*
United Provinces	108,470	*28·6*
Punjab	54,670	*14·4*
Other provinces	3,570	*0·9*
Average Total	**379,580**	*100·0*

Only very small quantities of saltpetre for chemical and medicinal purposes are imported into India by sea, but a considerable quantity comes from Nepal. During the past five years the imports from Nepal have, as shown below, averaged 4·156 cwts., as compared with 9·417 cwts. during the previous six years.

Trans-frontier imports.

Saltpetre imported from Nepal.

	Cwts.
1903-04	4,244
1904-05	2,872
1905-06	4,317
1906-07	4,595
1907-08	4,753
Average	4,156

But, although the saltpetre from Nepal constituted practically the whole of the imports in three of the years, the total annual imports averaged 6,077 cwts. This was largely due to an import in 1905-06 of 1,723 cwts. by land from Afghanistan, and of 4,848

cwts. by sea from Hongkong, making the total for the year 10,988 cwts.; and in 1907-08 of 2,621 cwts. imported by land from Khelat, making the total for the year 7,401 cwts. The annual values returned for the total imports give an average of £3,178·5 or of 10·46 shillings per cwt.

Tin.

Unworked occurrences.

Tin has a wider distribution than is generally recognised, and its minerals are often overlooked through the difficulty in distinguishing them from other heavy minerals. Isolated crystals of cassiterite or tin-stone have been found in pegmatites associated with gadolinite in the Palanpur State,[1] whilst in the Hazaribagh district of Chota Nagpur instances have been recorded of the accidental production of tin from river sands by the native iron smelters, in addition to the known occurrences of ores *in situ*. The latter are two in number—Nurunga and Chappatand—and the ore occurs in the unusual form of a cassiterite-granulite, which is very rich in tin.[2] The Nurunga occurrence has been opened up a little during the period under review, but has not proved to be workable.

Worked deposits.

The persistent attempts to work tin in Burma reported in the previous Review have been continued during the present quinquennium. In Burma cassiterite is obtained by washing alluvial gravels in the Mergui and Tavoy districts of South Burma, and in the Bawlake State, Karenni, Southern Shan States. But, although several syndicates and companies have been formed to develop and work these deposits, the production has hitherto been on a much smaller scale than might have been expected from the favourable reports that have been made as to their extent and richness. Thus table 96 shows that the amount of tin-ore raised annually during the years under review in Mergui, Tavoy, and Karenni, averaged 1,670 cwts. worth £10,992, compared with 1,645 cwts. worth £6,876 raised during the period 1898—1903 in Mergui and Tavoy alone. The average value set on the tin-ore during the two periods has increased from £83·5 per ton during the period 1898 to 1903 to

1 T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXI, p. 43, (1904).

2 L. L. Fermor, *op. cit.*, XXXIII, p. 235, (1906).

£131·9 per ton during the period under review. These production figures are to be regarded as very approximate, whilst the values ascribed to the output for the present quinquennium are much too high. The average value of tin during the five years 1904 to 1908, taking the mean of the quotations for Straits tin as given in the *Mining Journal* for the first week in January, April, July, and October of each year, was £150, so that the average value of 70 per cent. concentrates—this is what the so-called tin-ore usually is—would be £105 per ton. Hence, in view of the average figure of £132 per ton for the tin-ore produced during the quinquennium, it is probable either that some block tin has been included in the figure, or that the value of block tin has been by mistake ascribed to a certain proportion of the ore.

TABLE 96.—*Production of Tin-ore in Burma during 1904-1908.*

YEAR.	Tavoy.	Mergui.	Karenni.	TOTAL.	
				Quantity.	Value.
	Cwts.	Cwts.	Cwts.	**Cwts.**	£
1904	32	1,356	26	**1,414**	8,348
1905	31	1,464	32	**1,527**	9,916
1906	25	1,845	49	**1,919**	13,799
1907	13	1,506	65	**1,584**	11,882
1908	30	1,876	*Nil*	**1,906**	11,015
Average	*26*	*1,609*	*34*	*1,670*	*10,992*

Foreign exports of block tin.

The metal is exported partly in the form of block tin and partly as tin-ore, almost all of the foreign exports going to the Straits Settlements. These two, during the years 1903-04 to 1907-08, averaged 323 cwts. and 215 cwts. per annum respectively, as shown in table 97, the average total annual value of the foreign exports of Burmese tin being £3,053, compared with £3,144 for the period of the previous review.

TABLE 97.—*Exports of Burmese Block Tin and Tin-ore for the years 1903-04 to 1907-08.*

YEAR.	BLOCK TIN.		TIN-ORE.		TOTAL.	
	Quantity.	Value.	Quantity.	Value.	**Quantity.**	**Value.**
	Cwts.	£	Cwts.	£	**Cwts. (tin ore). (a)**	**£**
1903-04	281	1,678	197	899	**618**	**2,577**
1904-05	450	2,535	7	13	**682**	**2,548**
1905-06	401	2,346	25	105	**626**	**2,451**
1906-07	239	1,819	604	2,883	**962**	**4,702**
1907-08	243	1,981	243	1,007	**607**	**2,988**
Average	*323*	*2,072*	*215*	*981*	*699*	*3,053*

(a) Assumed that 3 cwts. of tin-ore are equivalent to 2 cwts. of block tin.

The foreign exports of Burmese tin account for only about one-third of the production; the remainder is partly exported in the form of block tin to other provinces of the Indian Empire, and partly consumed within the province. In some years, however, tinned iron sheets ('tin plates') have been entered in the trade returns as block tin, and consequently it is not now possible to give any accurate figures representing the distribution of the Burmese tin amongst the other provinces of India. The difference between the average total in tables 96 and 97 may, however, be taken as a rough measure of the consumption of Burmese tin in the Indian Empire, the amounts being 967 cwts. of tin-ore (equivalent to 645 cwts. of block tin) worth £7,939 per annum during the period under review.

Imports of block tin.

But the amount of Burmese tin consumed in the Indian Empire is a small quantity compared to the requirements of the country. Table 98 shows the amounts of foreign unwrought block tin which have been consumed in India during the period under review, and in addition to these quantities, smaller quantities of tin-plates are imported. By far the largest quantity of block tin imported into India comes from the Straits Settlements. Out of the average total of 30,469 cwts., the quantity coming from the Straits averaged 27,680 cwts. per annum. A curious feature connected with the

imports is the fact that the quantities of foreign tin imported have not increased since statistics of weight were first recorded in 1875-76. In that year the tin imported was reported to amount to 36,159 cwts., of which 31,479 cwts. came from the Straits.

TABLE 98.—*Consumption of Foreign Block Tin in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption.
	Quantity.	Value.		
	Cwts.	£	Cwts.	Cwts.
1903-04	40,358	260,840	3,253	37,105
1904-05	39,187	261 227	703	38,484
1905-06	20,939	159,469	844	20,095
1906-07	19,967	192,638	2,419	17,548
1907-08	31,892	286,902	7,985	23,907
Average	*31,469*	*232,215*	*3,041*	*27,428*

The country in which the Burmese tin-ore is found forms a belt—comprising Karenni, Tavoy, and Mergui—linking Yunnan, the south-west province of China, in which tin-mining is said to support a large population,[1] to the well-known tin-ore deposits of the Straits Settlements (now the Federated Malay States) to the south, from which, in 1908, about 58 per cent. of the world's supply of tin was obtained. In both Burma and Malaya by far the larger proportion of the ore is won from alluvial deposits, but a beginning has been made in working lode tin in both countries. During the period under review several syndicates and companies have been formed to work the Burmese tin deposits on a large scale (mostly in Mergui): but, judging from the fact that the average annual output of tin during the quinquennium has not increased, as compared with the period of the previous Review, it is evident that none of these companies have yet become large producers.

Mode of occurrence and economic considerations.

1 A. Leclère, 'Exploration géologique des Provinces chinoises voisines du Tonkin.' *C. R., 29eme Session, Assoc. Fr.*, 1900, ii, 916-926. Abs. *Trans. Inst. Mining Engineers*, XXII, 1901-02, 715. Also :—
W. F. Collins, 'Tin-Production in the Province of Yunnan, China,' *Bull. No. 63, Inst. Min. Met.*, pp. 1-14 (1910).

During 1907 and 1908. Mr. J. J. A. Page of the Geological Survey of India was engaged in investigating the tin deposits of the Mergui and Tavoy districts. The results of his investigations are summarised in the Annual Reports of the Department.[1]

Mergui district.

In the Mergui district, the principal hill ranges have a north to south trend and are composed mainly of granite, with flanking hills cut out largely of unfossiliferous schists, slates, sandstones, and quartzites, belonging to the so-called Mergui series. The granites appear to be intrusive into the sedimentary rocks; and are exposed in a series of bosses that do not form a continuous outcrop. There appears to be more than one generation of granitic rocks, and they are traversed by quartz-porphyry dykes. Isolated patches of strata, probably Tertiary in age, are found resting unconformably on the highly inclined Mergui slates and quartzites. The country is largely covered with laterite and recent alluvial deposits, and is very heavily jungle-clad; roads are scarce and most of the transport is effected along the numerous creeks.

The only tin-ore worked is cassiterite, which is widely distributed throughout the district and is invariably found near the granitic hills. The mineral is found under the following four conditions:—

(1) *As a constituent of decomposed pegmatite rich in tourmaline and muscovite, known locally as "kra";* at numerous localities.

(2) *In massive quartz-segregations in and on the outskirts of granitic hills.* Some of these segregations are several feet in thickness, and sometimes carry also wolfram, pyrite, and chalcopyrite, as for example at North Hill near Maliwun.

(3) *In quartz veins and stringers in ground adjacent to decomposing pegmatite.*

(4) *Hill-side talus accumulations due to the disintegration of classes (1), (2), and (3),* extending to gravel deposits along the stream valleys and in alluvial flats. These form the deposits most generally worked by the Chinese and Siamese immigrants.

The tin mines are divided by Mr. Page into the following groups:—

(1) *Mergui township;* the tin-stone averages 3 pounds per cubic yard.

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1 T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 38-41 (1908); XXXVIII, pp. 53-57 (1909).

(2) *Tenasserim township;* Thabalik, Tagu and Thendaw groups of mines; in one of the Thabalik mines the pay dirt was 10 feet thick and contained 15 pounds of tin-stone per cubic yard.

(3) *Bokpyin township;* Manoron, Yengan, Bokpyin, and Karathuri groups; there are many more tin mines in this township than in the whole of the rest of the district.

(4) *Victoria Point;* Maliwun and Banhuni groups; it is in the Maliwun area that the concession of the Burma Development Company is situated.

Most of the tin won in this district is obtained by Chinese and Siamese working on the alluvial deposits by ground-sluicing methods. The tin concentrates obtained are in some cases smelted locally and in others exported as ore to the Straits.

As the general result of his work is, Mr. Page finds [1] that cassiterite is widely distributed in the district and exists in quantities that should be payable on either side of the granitic axes of the chief ranges. The bulk of the cassiterite was formed in the numerous pegmatite intrusions into granites and other rocks, and the deposits now being worked have been derived from the disintegration of the pegmatites. It is possible that in some areas systematic prospecting would prove the existence of deposits suitable for dredging. The tin industry in this district is at present in a very backward condition. The causes of this being :—

(1) the lack of water during a considerable portion of the year, so that native workings can be carried on in most places for only three to five months,
(2) lack of capital,
(3) scarcity of labour,
(4) difficulties of transport,
(5) the dense jungle and overlying superficial deposits.

With adequate capital, however, and sufficient skill and foresight most of these difficulties can be overcome.

Of the syndicates and companies formed to work tin in Mergui only one need be mentioned, the Burma Development Syndicate,

1 Agreeing thus with his predecessors, Dr. T. Oldham (1855), Mr. Mark Fryer (1871) and Mr. T. W. H. Hughes (1889). See Hughes' 'Tin-mining in Mergui District,' *Rec. Geol. Surv. Ind.*, XXII, pp. 188-208, (1889). Also a separate report by Hughes published in Rangoon in three parts (1889-91).

Ltd., registered in London on 8th April 1903 with a capital of £5,000. A prospecting license was taken out on behalf of the Syndicate by Mr. A. B. Snow on the 13th March 1905 over the Maliwun property; this was converted to a mining lease on 1st July 1906. On October 8th of the same year the Syndicate appealed to the public for £65,000, about half of which was taken up. The Syndicate's concession is 3 square miles (1,955 acres) in area, and includes Khow Maung Hill (Centre Hill) and North Hill—granite hills containing stanniferous quartz segregations. The Syndicate also holds 40 acres of alluvial ground and 1,000 acres on which it is proposed to plant rubber. With the tin-stone on these concessions there is a certain proportion of wolfram. Concentrating plant and electric power plant are being erected, but no recent information as to progress has been received.

Tavoy district.

In the Tavoy district[1] Mr. Page found the tin mining industry to be practically at a standstill. In several places tin lodes have been found, some of them carrying a considerable or even a large quantity of wolfram. The cassiterite has been found in granite, in quartz veins at the slate-granite junction, and in quartz stringers penetrating sandstones near the granites, and in the slate of the Mergui series, some of the veins carrying wolfram, as well as tin. The veins discovered range from very small thickness up to 30 inches. Alluvial deposits containing tin-stone, wolfram and gold are found at many places, specially in the Hindu Chaung and its tributaries and along the eastern shore of the Heinza Basin.

The Golden Stream Syndicate with a capital of £25,000 was formed to work the alluvial gold and tin deposits in the Tavoy district. A prospecting license over 350 square miles in this district was obtained on the 20th September 1905. Gold and tin were found in the Hindu Chaung and its tributaries, and in certain tributaries of the Khamaung Thway, the northern branch of the great Tenasserim river (particularly in the Hindu Chaung and the Shwe Chaung, a tributary of the Hindu Chaung). Tin-ore was also found in the Hinda Chaung, a tributary of the Bean river, the southern branch of the great Tenasserim river. No recent information concerning this Syndicate is available.

[1] *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 57-60, (1909).

IV.—MINERALS OF GROUP II.

Alum and Aluminium-ore.

Alum.

The separation of sulphate of alumina from decomposed pyritous shales, and the preparation of the double sulphate of alumina and potash, by the introduction of nitre and wood-ashes, was formerly an important industry in a few places, and, on a smaller scale, was practised at numerous places in India. But the importation of cheap alum, principally from the United Kingdom, and its wide distribution by the gradually extending system of railways, have now nearly killed the native industry. Table 99 shows that during the five years under review the consumption of foreign alum in India has averaged 65,507 cwts. as compared with an average annual consumption of 66,086 cwts. during the preceding six years.

TABLE 99.—*Consumption of Foreign Alum in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption of foreign alum.
	Quantity.	Value.		
	Cwts.	£	Cwts.	Cwts.
1903-04	67,930	20,499	2,066	**65,864**
1904-05	60,170	18,389	2,264	**57,906**
1905-06	70,803	21,204	2,073	**68,730**
1906-07	72,344	21,294	2,463	**69,881**
1907-08	67,305	19,929	2,152	**65,153**
Average .	*67,710*	*20,263*	*2,203*	**65,507**

The only portion of India for which returns are available is the Mianwali district, Punjab, where, during the five years under review, there was an average annual production of 5,688 cwts. (284 tons) valued at £2,047 (see table 100),

The raw material is a pyritous shale found at Kalabagh, Kotki and other localities in the Isakhel tahsil. The average sulphur-content in the workable patches of these shales is, according to Mr. N. D. Daru,[1] 9·5 per cent. After roasting, the shale is lixiviated and concentrated. A mixture of crude chlorides, nitrates, and sulphates of sodium (chiefly) and potassium is then added, the alum crystallised out, and then fused in its water of crystallisation and allowed to recrystallise. The product is mainly soda-alum, and is used at Delhi, Hissar, Sirsa and other centres of the tanning and dyeing industries. The alkaline salts used are obtained by concentrating and crystallising the product of lixiviation of the scrapings of the soil of various localities in the Mianwali and Shahpur districts.

Pyritous shale, suited for the manufacture of alum, is also known at Dandot Colliery in the Salt Range.

Alunite.

Alunite, a sulphate of aluminium, is found associated with sulphur in veins traversing Siwalik clays in the Sanni sulphur mines in Khelat, Baluchistan.[2]

TABLE 100.—*Production of Alum in Mianwali District, Punjab, during the years 1904 to 1908.*

YEAR.	Quantity.	*Value.*
	Cwts.	£
1904	2,580	*700*
1905	7,126	*2,038*
1906	11,022	*4,000*
1907	5,511	*2,500*
1908	2,204	*1,000*
Average .	*5,688*	*2,047*

Bauxite.

In the previous Review, page 95, attention is drawn to the discovery that many of the lateritic deposits of India are highly aluminous, such aluminous varieties being identical with the substance known

1 *Rec. Geol. Surv. Ind.*, XXXVIII, p. 3, (1909).
2 G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 214, (1909).

as bauxite. Field work carried out since 1903 by the officers of the Geological Survey has revealed the existence of extensive deposits of this mineral substance in various parts of India, and chemical investigation in the Geological Survey Laboratory and at the Imperial Institute has shown that certain of the Indian bauxites compare very favourably with the Irish, French and American bauxites placed on the English market.

The richest areas yet discovered in India are the Baihir plateau in the Balaghat district, and the neighbourhood of Katni in the Jubbulpore district, both in the Central Provinces. But valuable ores have also been found in Kalahandi State and Chota Nagpur, Bengal, in Bhopal State, Central India, in the Satara district, Bombay, and in various parts of the Madras Presidency. The bauxites to which the most attention has been up to the present devoted are those of Balaghat and Jubbulpore. Eight analyses of specimens and samples of the Balaghat bauxites have given results ranging between the following limits :—

Alumina, Al_2O_3	51·62 to 58·83
Ferric oxide, Fe_2O_3	2·70 to 10·58
Titanic oxide, TiO_2	6·22 to 13·76
Silica, SiO_2	0·05 to 2·65
Combined water, H_2O	22·76 to 30·72
Moisture	0·40 to 1·14

corresponding to 71·2 to 80·8 per cent. of Al_2O_3 after calcination. With these may be compared the following figures showing the range of analysis of some Irish, French and American bauxites of commerce analysed at the Imperial Institute :—

Al_2O_3	42 to 63
Fe_2O_3	2 to 21
TiO_2	2 to 6
SiO_2	3 to 15
H_2O	12 to 26
Moisture	5 to 16

Two Katni bauxites gave the following analyses :—

	No. 1.	No. 2.
Al_2O_3	65·48	52·67
Fe_2O_3	3·77	7·04
TiO_2	11·61	7·51
SiO_2	0·38	1·26
H_2O	19·38	29·83

From these figures it will be seen that the Balaghat and Jubbulpore bauxites are of very high grade. There seems also to be little doubt that large quantities of the mineral are available, and the question therefore arises as to the commercial feasibility of making use of these deposits. There are three ways in which the Indian bauxites might be developed :—

(1) Simple export of the raw or calcined material to Europe or America for use in the alumina factories.

(2) Manufacture of pure alumina locally by extraction with alkali, and export of the pure oxide to European or American aluminium works.

(3) Manufacture of the metal in India.

The first proposal is impracticable on account of the low prices of raw bauxite at European ports (22*s*. to 23*s*. per ton is an ordinary price), whilst the third would involve a heavy capital outlay under untried conditions, and an elaborate preliminary investigation before power works could be erected. The second proposal involves much smaller risks, and it has been found on investigation that there are no technical difficulties in the way of manufacturing alumina from Indian bauxites;[1] and in this connection it is of interest to note that the price obtained for manufactured alumina in England varies from £12 to £38, according to its purity, and, to some extent, its physical condition. Several concessions have been taken out for working the bauxites of the Central Provinces and elsewhere, but with two exceptions little progress has been made in opening up the deposits.

In one case, the lateritic plateau of Yeruli, found by the Geological Survey to contain high-grade bauxites, was tested by means of a series of prospecting pits by Messrs. C. H. B. Forbes & Co. of Bombay. The result of their work was to show that the high-grade ores are too irregularly distributed to be worth working. The other exception is the area near Katni, Jubbulpore district, the principal locality being Tikari. The occurrence of aluminous laterite in this locality was first noted by Mr. F. R. Mallet in 1883.[2] Early in 1905, after the Geological Survey had drawn attention to the identity of aluminous laterites with bauxite, Mr. P. C. Dutt of Jubbulpore secured an exploring license over this area, and later

The Katni bauxites.

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[1] *Rec. Geol. Surv. Ind.*, XXXV, p. 29; XXXVI, p. 220.

[2] *Rec. Geol. Surv. Ind.*, XVI, p. 113.

prospecting licenses were taken out by Mr. Dutt and a syndicate formed by him, called the Bombay Mining and Prospecting Syndicate, with Messrs. C. Macdonald & Co., of Bombay, as Managing Agents. The objects of this syndicate are varied, including the manufacture of hydrated alumina, alum, and aluminium; of cement and lime; and of pottery, firebricks, etc.: materials for all these purposes being found within the bauxite concessions. The bauxite deposits have been prospected by means of a large number of pits and large quantities of ore proved, it is said; 32 tons of bauxite are reported as having been won in this area in 1908. Ten bulk samples submitted for analyses to Messrs. Maret Delatire and Maris of Paris yielded results ranging between the following limits :—

Al_2O_3	55·10 to 62·05
Fe_2O_3	2·20 to 7·80
TiO_2	0·85 to 10·88
SiO_2	0·44 to 2·00
Loss on heating	19·36 to 29·13
Not determined	0·05 to 0·37

A 16-ton wagon-load submitted to Dr. Roy of the Bengal Chemical and Pharmaceutical Works, Calcutta, has been favourably reported on for the manufacture of alum and hydrated alumina, and some pure alum manufactured. It is proposed to float a limited company to carry out the projects of the syndicate. It is to be hoped that the company, when formed, will confine itself to the manufacture of alumina at first and not attempt to extract the metal too early in its career.

On the subject of Indian bauxites, the following references may be consulted :—

(1) T. H. Holland, *Geol. Mag.*, Dec. IV, Vol. X, pp. 59—69, (1903).
(2) T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXII, pp. 95, 141—144, (1905).
(3) J. M. Maclaren, *Geol. Mag.*, Dec. V, Vol. III, pp. 536—547, (1906).
(4) T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXV, pp. 28—30, (1907).
(5) W. R. Dunstan, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 213—220, (1908).
(6) L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 374—380, (1909).

Also, on gibbsite :—

(7) L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIV, pp. 167—171, (1906).

Amber.

Production.

The production of amber during the five years 1904 to 1908 is shown in table 101. The average annual production was 104 cwts. valued at £6·2 per cwt. compared with 51 cwts. valued at £7·1 per cwt. during the six years 1898 to 1903. The three years 1904 to 1906 show a considerable increase over the production of the previous period: the falling off again in 1907 and 1908 has been attributed to the superior attraction for the Kachins of the rubber plantations. The right to collect a 5 per cent. *ad valorem* royalty on amber in the Myitkyina and Upper Chindwin districts is farmed out with the jadeite royalties (see page 120).

TABLE 101.—*Production of Amber in the Myitkyina District, Upper Burma.*

YEAR.	Quantity.	*Value.*
	Cwts.	£
1904	86	*838*
1905	126	*945*
1906	216	*709*
1907	44	*385*
1908	49	*364*
Average	*104*	*648*

Occurrence.

The Burmese diggings for amber are situated in the Hukong valley in the Nangotaimaw hills near Lalaung village in about lat. 26° 10′ and long. 96°. The substance is found in clays of probable Miocene age, and fragments of amber have been similarly found in association with beds of this age in other parts of Burma, for example, at Mantha in the Shwebo district, and on the oil-field of Yenangyat in the Pakokku district. Most of the material is brought from the Hukong valley in Upper Burma to Mandalay, where beads for rosaries, *nadaungs* (ear-cylinders), and other trinkets for personal ornament are made from the transparent varieties.

Chemical and physical properties.

The amber of Burma differs in chemical and physical characters from previously known varieties, and the name burmite has been consequently suggested for it as a specific distinction.[1] The well-known amber of Eastern Prussia contains from 2½ to 6 per cent. of succinic acid, and is consequently known to the mineralogist as succinite, but the Burmese amber contains no succinic acid, though the products of its dry distillation include formic acid and pyrogallol. Its ultimate chemical composition has been determined to be as follows:—

Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
	100·00

The specific gravity of burmite varies between 1·030 and 1·095. It is distinguished from many other amber-like resins by its superior hardness and greater toughness, which render it fit for carving and turning. It possesses a peculiar fluorescence, like that which distinguishes the Sicilian variety simetite.

Apart from the occurrence of a large percentage of discoloured and opaque pieces, many of the large fragments obtained are damaged by cracks filled in with calcite; but otherwise there appears to be a large quantity of material which might be put on the market with profit.

Antimony.

A mining lease to work the well-known antimony-ores (stibnite with oxides) near the Shigri glacier in Lahaul was granted in 1904 to Colonel R. H. F. Rennick. The stibnite lodes are situated at an elevation of 13,500 feet, and are associated with gneissose granite. To reach the locality it is necessary to cross the Hamta Pass (14,500 feet), work is possible for two or three months only every year, and labour and supplies have to be brought from the nearest village, 3½ marches away. In spite of these difficulties, however, Colonel Rennick succeeded in 1905 in shipping over 400 maunds (15 tons) of stibnite to England. Since then he has quarried a like quantity and thinks his deposits extensive enough to yield 200 to 400 maunds of stibnite a year, so as to bring in a fair profit, even with

[1] O. Helm, *Rec. Geol. Surv. Ind.*, XXV, p. 180, (1892), and XXVI, p. 61, (1893).

star regulus as low as £34 a ton. (It is now, October 1909, £28 to £30.) The stibnite has yielded 6 dwts. of gold per ton. Galena and blende are also found in the same locality, the former being argentiferous.

The existence of an antimony deposit of considerable size in the Möng Hsu State, one of the Southern Shan States, is indicated by the return amongst the mineral statistics for Burma for 1908 of an output, under a mining lease held by Mr. W. R. Hillier of Lashio, of 1,000 tons of antimony-ore, of which 11 tons were sent to London for assay and valuation. No information is available concerning this occurrence.

In 1905, stibnite with cervantite was found in the Northern Shan States,[1] whilst the lead slags at Shekran in Jhalawan, Baluchistan, are antimonial.[2] The tetrahedrite found in the Sleemanabad copper lodes[3] is also highly antimonial.

Arsenic.

Occurrence.

The chief indigenous source of arsenic is the orpiment mines of Chitral, where the mineral is exploited by the Mehtar of Chitral. The output of these, however, has latterly fallen off considerably, being under 10 tons in 1905-06. The occurrence of orpiment near Munsiari in Kumaon has long been known,[4] small quantities of this mineral and of realgar, the other sulphide, being sold in the bazaars of Northern India; but it was not till 1906, when Messrs. G. deP. Cotter and J. Coggin Brown found scattered fragments of both minerals lying on the moraine material of the Shankalpa glacier, that any precise locality was ascertained. The ore was not found *in situ*, but had probably come from the hill-face immediately above.[5] Large lumps of leucopyrite, an arsenide of iron, have been found in the pegmatites of the mica-mining field near Gawan in Hazaribagh district,[6] and other arsenides have been found associated with pyritous lodes in various places, but no attempt has been made to recover arsenic from these occurrences. The existence of two or three species of arsenates has been noticed in the Kajlidongri manganese mine, Jhabua State, Central India; and in the Sitapar

1 L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234, (1906).
2 G. H. Tipper, *ibid.*, XXXV, p. 51, (1907).
3 L. L. Fermor, *ibid.*, XXXIII, p. 62, (1906).
4 A. W. Lawder, *Rec. Geol. Surv. Ind.*, II, p. 88. (1869).
5 *Ibid.*, XXXVI, p. 129. (1908).
6 T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 51, (1902).

manganese mine, Chhindwara district, Central Provinces;[1] but no attempt has yet been made to use them commercially. Nevertheless, it is possible that it might pay to treat selected pieces of arsenical ore from the latter locality.

Exports and imports.

Details with regard to the production and use of Indian arsenic are not available, but there has been a considerable trade in both Indian and foreign arsenic, presumably in the form of white arsenic.

Table 102 shows the extent of this trade for the period under review, but does not include the trade in orpiment, which is shown separately. By comparison with page 98 of the previous review it will be seen that whilst the annual imports of foreign arsenic have remained fairly constant, there has been a considerable decrease in the small annual export of Indian arsenic.

TABLE 102.—*Average Annual Exports and Imports of Arsenic for the years 1903-04 to 1907-08.*

—	Quantity.	Value.
	Cwts.	
Exports of Indian Arsenic—		
To Straits Settlements	169	
" Other Countries	15	
TOTAL	184	£246
Imports of Foreign Arsenic—		
From United Kingdom	208	
" Germany	631	
" Belgium	246	
" China	1,082	
" Straits Settlements	99	
" Other Countries	104	
TOTAL	2,370	£3,607
Re-export of Foreign Arsenic	*61*	*£89*

1 L. L. Fermor, *Mem. G ol. Surv. Ind.*, XXXVII, pp. 218-219; (1909).

Orpiment, the yellow sulphide of arsenic, is largely imported into Burma from Western China for use mainly as a pigment. During the five years 1903-04 to 1907-08, the average annual imports across this frontier amounted to 6,701 cwts., valued at £8,130, or 24 shillings per cwt. (see table 103), as compared with 9,551 cwts. valued at £11,470, or 24¼ shillings per cwt., during the six years 1897-98 to 1902-03.

Chinese orpiment.

The mineral is used as a pigment in the manufacture of Indian ornamental lac-wares and the Burmese lacquer-work, in which the favourite greens of the Pagan workers are produced by mixtures of indigo and orpiment, and the so-called gold-lacquer of Prome by powdered orpiment and gum. It is used also for the designs on the Afridi wax-cloths.[1]

TABLE 103.—*Imports of Orpiment from Western China.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1903-04	5,678	*6,611*	23·28
1904-05	5,285	*6,486*	24·54
1905-06	6,663	*8,002*	24·02
1906-07	8,095	*9,935*	24·54
1907-08	7,784	*9,616*	24·71
Average	*6,701*	*8,130*	*24·26*

Asbestos.

Attempts to develop asbestos in India have not yet met with much success. The deposits that have attracted most notice occur in Merwara, Rajputana; in Garhwal in the United Provinces; in Bhandara in the Central Provinces; and in Hassan, Mysore State. An output in 1906 of 412 cwts. from Hassan is recorded, and, in 1908, of 18 tons of crude asbestos from the Tumkhera Khurd deposit in Bhandara.

[1] G. Watt, Indian Art at Delhi, 1903, pp. 211, 221, 222, 231.

Small quantities of fibrous serpentine have been found in the Singhbhum district, Chota Nagpur, and in South Mirzapur.

Barytes.

Barytes, or heavy-spar, has many applications in the arts, such as giving weight to paper, adulterating white lead, and as a flux in metallurgy (particularly for ferro-manganese). It seems to be widely distributed throughout the Indian Empire, but, with one exception, has not, as far as we know, been turned to account. At Sleemanabad in the Jubbulpore district, one of the copper lodes is rich in barytes.[1] A wagon-load (about 16 tons) of this was despatched to Calcutta about the year 1904 for use in the works of the Shalimar Paint, Colour and Varnish Company, Ltd. The quality was found to be poor, and a nominal value assigned to it of Rs. 7 per ton.

Other occurrences concerning which information has been obtained during the quinquennium are :—

(1) Narravada, Nellore district, Madras: barytes veins in mica schist, into which they pass in places.[2]

(2) Bawdwin Silver-lead Mines, Northern Shan States: in considerable quantity at one spot.[3]

(3) Khelat and Las Bela States, Baluchistan: fairly abundant in the Belemnite shales; the most accessible locality is Pabni Chauki, about two days' march from Karachi.[4] Barytes has also been found in the Middle Khirthar shales.

Another well-known locality is Alangayam, Salem district, Madras, where certain gneisses are traversed by a plexus of quartz-barytes veins.[5]

Borax.

No undoubted occurrence of borax is known within British Indian territory, and the material exported, which during the last five years has averaged annually 4,959 cwts. of a value of £6,568 (table 104), is practically all obtained from Tibet and Ladakh, being imported across the frontier into the Punjab and United Provinces.

1 L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 62, (1906).
2 H. C. Jones, *ibid.*, XXXVI, p. 233, (1908).
3 T. D. LaTouche, and J. C. Brown, *ibid.*, XXXVII, p. 255, (1909).
4 G. H. Tipper, *ibid.*, XXXVIII, p. 214, (1909).
5 T. H. Holland. *ibid.*, XXX, p. 236, (1897).

The word *tincal* by which it is known in the bazars is possibly a corruption of the Tibetan name for borax, and is in common use on the Punjab frontier, where one meets, in the Himalayan passes, herds of goats and sheep coming down in the spring from Tibet, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

TABLE 104.—*Exports of Borax by Sea from India during the years 1903-04 to 1907-08.*

YEAR.	QUANTITY. Cwts.	QUANTITY. Metric Tons.	Value.	Value per cwt.
			£	Shillings.
1903-04	5,333	*271*	7,011	26·29
1904-05	4,454	*226*	5,558	24·95
1905-06	4,146	*210*	5,366	25·88
1906-07	5,613	*285*	7,687	27·39
1907-08	5,247	*267*	7,219	27·51
Average	*4,959*	*252*	*6,568*	*26·48*

In addition to the borax sent by sea to foreign countries, small quantities cross the frontier into Nepal, Kashmir, Khelat and Afghanistan. During the five years, 1903-04 to 1907-08, these trans-frontier exports of borax have averaged 82 cwts. a year, with an average total value of Rs. 1,769 (£118) or Rs. 21·6 (29*s*.) per cwt. The export trade has very seriously declined. Twenty-five years ago the borax sent out of India amounted to over 16,000 cwts. a year, valued at £24,000. At that time the principal part of the material exported went to the United Kingdom (14,134 cwts. in 1883-84), but with the discovery of large deposits of calcium borate in America the demand for borax from India ceased, and now the only large customers are the Straits Settlements and China the latter having taken 4,314 cwts., and the former 472 cwts., of the average annual total of 4,959 cwts. exported.

The amount of borax imported into India across the frontier has averaged (as shown in table 105) 19,946 cwts. of the value of

£16,336, as compared with an average annual figure of 21,955 cwts. valued at £17,369 for the period of the previous review; whilst the amount (presumably refined borax) imported by sea has averaged (as shown in table 106) 2,436 cwts., of the value of £1,572, this being a very large increase over the average annual figure —257 cwts. worth £261—for the earlier period. Adding the land and sea imports, it is seen that there has been a very slight decrease in the consumption of borax in India from 17,655 cwts. per annum during the period 1897-98 to 1902-03 to 17,341 cwts. per annum during the period 1903-04 to 1907-08.

TABLE 105.—*Imports of Borax by Land during the years 1903-04 to 1907-08.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1903-04	25,101	*19,887*	15·84
1904-05	19,025	*14,927*	15·69
1905-06	15,207	*12,923*	16·99
1906-07	21,506	*17,391*	16·17
1907-08	18,890	*16,502*	17·47
Average .	*19,946*	*16,326*	*16·37*

TABLE 106.—*Imports of Borax by Sea during the years 1903-04 to 1907-08.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1903-04	848	*542*	12·78
1904-05	1,500	*907*	12·09
1905-06	1,700	*1,019*	11·99
1906-07	2,798	*1,852*	13·24
1907-08	5,332	*3,542*	13·28
Average .	*2,436*	*1,572*	*12·90*

Of the amounts brought across the frontier, and shown in table 105 to have an annual average of 19,946 cwts., 711 cwts., or 3·6 per cent., came from Ladakh, whilst 19,235 cwts., or 96·4 per cent., came from Chinese Tibet.

Of the amounts imported by sea, and shown in table 106 to have an annual average of 2,436 cwts., 2,190 cwts., or 89·9 per cent., came from the United Kingdom, 209 cwts., or 8·6 per cent., came from Germany, and the remainder from other countries.

The borax obtained in the Puga valley of Ladakh, Kashmir, is deposited from hot springs associated with sulphur deposits, which probably represent the final phase of declining volcanic action. The material collected in Tibet is obtained from salt lakes, which have possibly obtained their borax in a similar way from hypogene sources. In other parts of the world, as in California, Argentina, Bolivia, and Chile, deposits of calcium borate, colemanite, are worked for their boracic acid, besides the borax of salt lakes and marsh deposits. In Italy borax is obtained from volcanic fumaroles.

Building Materials.

If the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country. The attempt made to obtain returns of building stones, road-metal, and clays used in India was abandoned when it was shown, in 1899, that the returns could not possibly rank in value much above mere guesses.

In the absence of statistics, it is difficult to express shortly the trade in a material so widespread as common building stone. There are, however, a few features which are specially developed in, if not peculiar to, India. In the southern part of the Peninsula, various igneous rocks—the charnockite series near Madras, and the gneissose granites of North Arcot and Mysore—are largely used; in the centre, slates and limestones from the Cuddapah series, and basalt from the Deccan trap-flows are quarried. In Central India, the Central and United Provinces, the great Vindhyan system provides incomparable sandstones and limestones, while in Bengal and the Central Provinces the Gondwana sandstones are used on and near the coalfields. In the Narbada valley the so-called coralline limestone of the Bagh series forms an excellent building stone with a certain claim to inclusion in the ornamental class. Among the

younger rocks the nummulitic limestones in the north-west and in Assam are largely quarried, while the foraminiferal Porbandar stone in Kathiawar is extensively used in Bombay and Karachi.

The abundant development of concretionary carbonate of lime in the great alluvial plains, and the extensive development of laterite on the Peninsula and in Burma are dependent, in their more pronounced forms, on conditions peculiar to tropical climates, and these two substances, the so-called *kankar* and laterite, are about the most valuable assets in building material possessed by the country.

The three great physical divisions of India, being the result of three distinct geological histories, show general contrasts in the materials available for simple as well as ornamental building purposes. In the great alluvial plains, buildings of importance are usually made of brick, but the surrounding tracts furnish a supply of stone, which is steadily increasing with improved facilities for transport. The monotonous line of brick and stucco buildings in Calcutta is being relieved by the introduction of Vindhyan sandstones from Mirzapur and the calcareous freestones and buff traps brought from the western coast. But the use of Italian marbles, mainly for floorings and, in a smaller way, the introduction of polished granite columns and blocks from Aberdeen and Peterhead, have continued, mainly because these materials, which are no better than, and possibly on the whole inferior to, those of Indian origin, are placed on the market at cheap rates and in a manner suitable to the immediate requirements of the builder and architect.

Imports.

During the present quinquennium, the value of building and engineering materials imported from foreign countries into India has had an average value of £315,240, exclusive of stone and marble, which have averaged £26,574 annually during the same period. The substances included in the trade statistics under the heading of building materials and entered into the above total comprise asphalt, bricks and tiles, cement, chalk and lime, clay and earthernware piping. The values of some of these are given in the section on clays. The quantity of cement imported annually, during the five years 1903-04 to 1907-08, has averaged 74,667 tons valued at £187,368; and the annual imports of chalk and lime during the same period have averaged 1,722 tons valued at £1,932.

Ornamental building stone.

It is naturally surprising to find that a country which owes its reputation for architectural monuments as much to the fact that it possesses an unlimited supply of ornamental building stone as to the genius of its people is dependent on foreign supplies to the extent indicated by these import returns. It can hardly be an accident that each dynasty which has existed in India since the wonderful Buddhist topes of Sanchi and Bharhut were erected has been marked by the erection of great monuments in stone, and there can be little doubt that the abundance of suitable material has been an important contributory cause in the growth of India's reputation for architecture.

Besides the architectural remains left by the Buddhists, there are famous works in stone by the Hindus of the eighth to tenth centuries, including the great Dravidian temples of Southern India, mostly built of granites and other crystalline rocks, and the richly ornamented buildings of Orissa and of Chanda, built of Gondwana sandstones. The Pathans and Moghals utilised both the Vindhyan sandstones of Central India and the beds of marble in Rajputana for building their magnificent mosques, palaces, and tombs in the cities of Northern India. It is only necessary to mention here Akbar's city of Fatehpur Sikri, where the red and mottled sandstone of the Bhanrer series was used, and the famous Taj, built mainly of white Makrana marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and blood-stones from the Deccan trap, and red jasper from the Gwalior (Bijawar) series.

The delicate and intricate carvings, for which some varieties of the Indian sandstone are so well suited, are admirably shown in an "Illustrated Catalogue of Ornamental Carved Stone in Gwalior" published by the Department of Commerce and Industry, Gwalior, in 1909. Amongst stones concerning which information has been recently acquired, the flagstone quarried at Sikosa in the Bilaspur district, Central Provinces, is worth mentioning. It is a fine-grained flaggy impure limestone and is being extensively used for roofing and flooring in the Government buildings at Nagpur.

Although, in most cases, reliable statistics concerning the production of building stones in India are not obtainable, yet it is proposed to give here such figures as are available, excluding

those relating to marble and slate, which are treated in separate sections.[1]

Granite and gneiss.

Gneissose granites and gneisses are used as building stones and for road-metal in many parts of Peninsular India, particularly in the Madras Presidency, for which, however, no returns are available. Figures of production and value for Burma and Coorg are given in table 107. The Burmese production of granite and gneiss increased from 7,991 tons in 1904 to 27,781 tons in 1907, and then suddenly leaped up to 340,939 tons in 1908. This is due partly to the development of the gneissose granite quarries in the Thatôn district, which began in the year 1907, and yielded 270,585 tons of granite in 1908; and partly to an output of 51,410 tons in the Mandalay district. The stone from Thatôn was used extensively by the Burma Railways Company and on the Town Lands Reclamation Works in Rangoon. An examination of the quarries by the Geological Survey has shown that the granite exists in large quantities, and production on a still more extended scale may be expected in the immediate future.

TABLE 107.—*Production of Granite and Gneiss during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value.*
	Tons.		Tons.	£	Tons.		Tons.	£	Tons.		Tons.	
Burma.	7,991	*873*	9,946	*1,349*	22,575	*2,645*	27,781	*2,450*	340,939	*19,122*	81,846	
Coorg.	20,173	*4,034*	27,788	*5,450*	23,638	*4,728*	13,462	*2,692*	16,869	*3,274*	20,286	*4,035*
Total	28,164	*4,907*	37,734	*6,799*	46,213	*7,373*	41,243	*5,142*	357,808	*22,396*	102,122	*9,323*

Sandstone.

The available figures for the production of sandstone in India are shown in table 108. They refer practically entirely to two provinces.

[1] Figures relating to granite and gneiss, limestone, *kankar*, laterite, etc., in Mysore for the years 1904 to 1906 are given in the reports of the Chief Inspector of Mines, Mysore. They are not quoted on account of their admitted inaccuracy.

Those shown for the United Provinces refer to the output of Upper Vindhyan sandstone from the quarries at Chunar in the Mirzapur district, which has averaged 96,247 tons a year, valued at £11,404. In Burma, sandstone is quarried in many districts, amongst which may be mentioned Bassein, Henzada, Thatôn, Minbu, Kyaukse, Pakôkku, Shwebo and Akyab. In Rajputana, sandstone is quarried in Jaisalmer and near Bhadasar in Bikanir.

The Cambrian sandstone of the Salt Range, known as 'magnesian sandstone' is being largely quarried at Jutum and Bhaganwala for canal works, but no statistics are available.

TABLE 108.—*Production of Sandstone during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.		AVERAGE.	
	Quantity	*Value*	Quantity.	*Value*	Quantity	*Value*	Quantity	*Value*	Quantity.	*Value*	Quantity.	*Value.*
	Tons	£	Tons	£	Tons.	£	Tons	£	Tons	£	Tons.	£
Burma	80,370	*10,818*	96,918	*8,863*	93,252	*7,268*	78,786	*5,432*	75,422	*5,920*	84,956	*7,596*
Rajputana	6,358	*280*	..		.		270	*12*	247	*29*	1,375	*68*
United Provinces	76,484	*6,987*	99,850	*12,727*	101,745	*12,690*	103,514	*12,158*	99,644	*12,158*	96,247	*11,404*
Total .	**163,212**	*18,085*	**196,798**	*21,590*	**194,997**	*19,958*	**182,570**	*17,602*	**175,313**	*18,107*	**182,578**	*19,068*

The subject of building materials naturally includes limestone used as a building stone, and the two derived products—lime and cement; these are obtained, obviously, from the most conveniently situated deposits of limestones, such as those of the Upper Vindhyan series worked near Sutna in the Rewah State by the Sutna Lime and Stone Co., Ltd.; those of the Lower Vindhyan series worked at Katni in the Jubbulpore district by Messrs. Cook and Sons and others; those worked in the Cuddapah series at Bisra and Rourkela in Gangpur State by the Bisra Stone Lime Company; or the various bands of crystalline limestones in Madras, Central India, and Rajputana, and the Nummulitic limestones of Assam. Such

Limestone.

figures as are available for the production of limestone during the period under review are given in table 109. The production of the Bisra Stone Lime Company in Gangpur has averaged 39,211 tons valued at £1,307. The production of the Sutna Lime and Stone Company in Rewah may be gauged from the quantities despatched from the works during the five years 1904 to 1908. The quantity of limestone has averaged annually 46,826 tons valued at £3,317; the unslaked lime has averaged 18,348 tons valued at £10,314; the slaked lime has averaged 1,412 tons valued at £640; and the stone setts have averaged 198,482 pieces valued at £1,323. As is shown by these figures, much of the limestone is not converted to lime; it is instead railed a distance of 530 miles to the Barakar Iron Works, where it is used as a flux in the blast furnaces.

The production shown for the Central Provinces refers entirely to Katni, where the limestone quarries come under the control of the Indian Mines Act. The quantity raised has varied from 47,836 tons in 1906 to 99,885 tons in 1908, the average for the quinquennium being 70,034 tons worth £4,494. The average daily labour employed is shown below separately for each year, the average for the period being 2,411 persons. The number of deaths has been 12, giving an average death-rate of 1·00 per 1,000.

	Persons.
1904	1,917
1905	2,093
1906	1,856
1907	2,993
1908	3,195

A considerable proportion of the deaths was due to an accident on the 10th of February 1908, in which a large mass of earth and rock slipped down a bedding plane into a quarry and killed seven men.

A very small proportion of the limestone, shown as quarried in Eastern Bengal and Assam, comes from the Lakhimpur district and Manipur, practically the whole of the output being from the Khasi and Jaintia Hills, where the nummulitic limestone is being worked by the Sylhet Lime Company, Ltd. The output from this province has varied from 76,614 tons in 1906 to 124,222 tons in 1904, the average quantity being 94,800 tons worth £7,232.

As regards the other areas reported as producing limestone, that in Baluchistan comes from the Las Bela State; the limestone of Burma comes from many districts, the most important of which are

Sagaing, Kyaukse, Thayetmyo, Thatôn, Mandalay, Myingyan and Meiktila; in Mysore, the most important districts are Mysore, Hassan and Kolar, but the statistics from this province are very unreliable. The small production reported from the Punjab comes from the Hoshiarpur district, whilst the output reported from Rajputana comes chiefly from Sirohi State, and also from Dhalayan and Alwar.

Kankar.

One of the most widespread and interesting sources of lime is the material generally known by the name of *kankar*. The commonest mode of occurrence is in the great alluvial deposits, in which the calcareous substances have segregated from the rest of the materials and have grown into irregular lumps like flints in chalk, including in the concretions a certain amount of the argillaceous substances, which, when the *kankar* is burnt, is present in a proportion not far removed from that necessary to produce a hydraulic lime.

TABLE 109.—*Production of Limestone during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.		AVERAGE	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Baluchistan	..	..	..	..	..	..	521	*54*	66	*7*	117	*12*
Bengal (*a*)	34,342	*1,145*	33,500	*1,117*	35,185	*1,173*	48,550	*1,618*	44,480	*1,483*	39,211	*1,307*
Burma	68,361	*11,854*	42,007	*5,543*	47,289	*4,288*	28,152	*3.995*	66,076	*6,338*	50,377	*6,404*
Central India (*b*)	49,991	*3,541*	52,488	*3,718*	45,472	*3,221*	42,037	*2,978*	44,144	*3,127*	46,826	*3,317*
Do (*c*).	29,819	*2.107*	30,644	*2,165*	29,961	*2,117*	37,174	*2,627*	45,758	*3,234*	34,671*	*2,450*
Central Provinces. (*d*)	49,847	*2,519*	92,170	*4,514*	47,836	*2,580*	60,432	*3.937*	99,885	*8,922*	70,034	*4,494*
Eastern Bengal and Assam. (*e*)	124,222	*9,895*	90,982	*7,231*	76,614	*5,572*	82,449	*6,789*	99,735	*6,672*	94,801	*7,232*
Punjab (Hoshiarpur).	1,000	*67*	1,000	*67*	1,000	*67*	1,200	*111*	1,400	*129*	1,120	*88*
Rajputana	18,015	*2.750*	40.708	*8,166*	9,437	*2,470*	10,642	*695*	8,949	*576*	17,550	*2,932*
TOTAL	**375,597**	*33,878*	**383,499**	*32,521*	**292,794**	*21,488*	**311,157**	*22,804*	**410,493**	*30,488*	**354,707**	*28,236*

(*a*) Output of Bisra Stone Lime Company in Gangpur State, valued at As. 8 per ton at the quarries.
(*b*) Limestone despatched by the Sutna Stone and Lime Company from Rewah.
(*c*) Limestone converted to lime before despatch by the Sutna Stone and Lime Company.
(*d*) Output of the Katni quarries under the Mines Act.
(*e*) Derived almost entirely from the Khasi and Jaintia Hills with very small quantities from Lakhimpur and Manipur.
* Afterwards converted into an annual average of 19,760 tons of slaked and unslaked lime, valued at £10,954.

Laterite. The curious superficial rock known as laterite is widely distributed over the whole of the Peninsula of India and in Burma. It is very widely used as road-metal and as a building stone for culverts and buildings; but, in most cases, no statistics are collected. In table 110 are given the statistics for Burma and Coorg. The annual Burmese output during the period averages 237,453 tons worth £25,997, giving an average value of 2*s*. 2*d*. (Re. 1-10) per ton. The output comes from some twenty districts, but by far the most important are Hanthawaddy, the average annual output from which is over 91,000 tons; Prome (output in 1908 nearly 59,000 tons); Thaton; the Ruby Mines (output in 1905 nearly 100,000 tons); and Meiktila.

TABLE 110.—*Production of Laterite in Burma and Coorg during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.		Tons.		Tons.		Tons	
Burma.	194,822	*20,781*	261,689	*29,688*	242,164	*26.592*	240.777	*27,152*	247,814	*25,773*
Coorg .	771	*51*	1.662	*277*	1,285	*86*	1.029	*68*	2[illegible]	
TOTAL	195,593	*20,832*	263,351	*29,965*	243,449	*26.678*	241,806	*27,220*	247,839	*25,775*

Gravel. The mineral returns of Burma regularly give details of the production of gravel in various districts; the total figures are—

				£
1904	39,610	tons	valued at	2,620
1905	50,462	„	„ ..	2,734
1906	66,125	„	„ ..	3,624
1907	49,573	„	„ ..	2,239
1908	92,444	„	„ „	6,201
Average	*59,643*			*3,484*

The most important districts are Lower Chindwin, Tavoy, Henzada, Minbu and Meiktila. The material is used for the repair of roads.

Clays.

Importance of clay as a mineral product.

The important part played by clay in the industrial development of a country is not generally recognised, but can easily be illustrated by reference to the mineral statistics of two such industrially advanced countries as the United Kingdom and the United States, for which see table 2 on page 12. From this it is seen that in 1907 clay ranked fourth in value amongst the mineral products of each country. The output for the United Kingdom in that year was 14,827,895 statute tons valued at £1,850,387. The figures for the United States relate not to the raw material, but to the products manufactured therefrom, and the magnitude of the total value—£32,637,037—can be grasped when it is pointed out that this is between four and five times the value of the total Indian mineral output for the same year of all minerals for which statistics are available.

Production in India.

No statistics approaching any degree of completeness are obtainable to show the extent of the undoubtedly great industrial value of the clays in India. They include the common clays used all over the country for the manufacture of bricks, tiles and the cheaper forms of pottery; finer varieties used for glazed pottery, which in places has obtained a reputation for artistic merit; fire-clays raised in considerable quantities on some of the Gondwana coal-fields; and fuller's earth, which is mined in the Central Provinces and in Rajputana.

Such statistics as are available will be given here. For Burma fairly complete returns are available, stated separately for each district, the most important districts being Myingyan and Hanthawaddy. The output for the five years under review is summarised in table 111, from which it will be seen that the average annual output has been 1,275,668 tons valued at Rs. 10,42,959 or £69,530,

giving an average value of 13 annas or pence per ton. These clays are common brick and potter's clays.

TABLE 111.—*Production of Clay in Burma for the years 1904 to 1908.*

—	Quantity.	Value.
	Tons.	£
1904	432,708	*22,351*
1905	1,075,098	*73,862*
1906	2,936,992	*110,469*
1907	827,439	*50,394*
1908	1,106,105	*90,577*
Average	*1,275,668*	*69,530*

For the Central Provinces the following statistics are available of the production of fuller's earth at Katni in the Jubbulpore district, where it is found in the Lower Vindhyan series :—

	Quantity.	Value.
	Tons.	£
1904	98	33
1905	170	57
1906	112	37
1907	112	27
1908	84	28

A form of fuller's earth known as *multani-matti* is also worked in the States of Bikanir and Jaisalmer in Rajputana. The amount raised in 1904 was returned as 534 tons.

Pottery clays are worked in various parts of India, amongst which may be mentioned Jubbulpore (from the Jubbulpore division of the Gondwanas).

In addition to the common clays used by the native potter in making common earthenware articles by means of the potter's wheel, there are in India many clays of finer quality used in large pottery works, such as those of Jubbulpore and Raniganj, where, however, the chief productions are drain-pipes, roofing and flooring tiles, fire-bricks, etc. There can be little doubt that India possesses also all the materials necessary for the manufacture of porcelain of the highest quality, such materials being found in the Jubbulpore district and the Rajmahal Hills.

The China-clay and fire-clay deposits of the Rajmahal Hills have recently been investigated by Mr. Murray Stuart,[1] who reports most favourably on their suitability for manufacturing porcelain and fire-bricks of the highest quality.

The Calcutta Pottery Works has been using kaolin from Mangal Hat in the latter area and has succeeded in producing cups, saucers, jugs, and ornaments of common white porcelain. An attempt is now being made by the Bombay Mining and Prospecting Syndicate (see page 212), so we are told, to organise the manufacture of porcelain at Katni. Tests made on a small scale have shown the suitability of the local materials for this purpose.

Testing of Indian clays.

During the period under review, a series of 95 samples of Indian clays was subjected to a critical examination at the Imperial Institute, and a report on them has been submitted by Professor W. R. Dunstan. The clays were carefully inspected, and a number of samples typical of the various groups were selected and submitted to complete chemical analysis. The remainder were subjected to working and firing trials with a view to the observation of their plasticity, refractoriness, and the nature of the product obtained on firing, which are the properties on which the commercial and manufacturing value of clays depend.

The series of clays are divided into two groups, (1) kaolins and (2) terra-cotta clays, the latter group comprising by far the larger number of the samples.

The *kaolins* examined are usually of inferior quality, and not in a sufficiently good mechanical condition to be suitable for the manufacture of thin wares such as those produced by 'slip' casting, though it is probable that by careful levigation some of them could be rendered suitable for working by this process.

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1 *Rec. Geol. Surv. Ind.* XXXVIII, pp. 133-148, (1909).

The *terra-cotta* clays are suitable for the manufacture of stoneware, ornamental vases and tiles, and bricks of good quality. The following analyses are given :—

—	1	2	3	4	5	6
Potash	0·61	0·21	*Nil*	0·24	0·24	0·07
Soda	0·41	0·25	*Nil*	0·72	0·51	0·26
Lime	1·85	0·13	0·26	*Nil*	0·46	0·30
Magnesia	1·32	0·54	1·63	0·48	3·09	*Nil*
Manganous oxide	0·12	..	*Nil*	..	..	..
Ferrous oxide	0·67	0·45	0·58	0·51	4·02	2·38
Ferric oxide	0·66	1·61	1·16		3·47	4·81
Alumina	32·75	24·82	21·06	13·04	20·28	21·22
Titanic oxide	0·51	..	0·35	..	0·61	trace
Silica	46·31	64·06	69·95	80·15	56·21	61·43
Carbon dioxide	2·02	..	0·02	..	2·05	0·72
Water	12·40	7·70	4·69	4·75	8·86	9·42
	99·63	99·77	99·70	99·89	99·80	100·61

NOTES.—No. 1. Prepared white kaolin ; from N. Arcot, Madras.

No. 2. Soft pale grey kaolin ; from Hoshangabad, Central Provinces.

No. 3. Soft white kaolin with some pinkish material ; from Bangalore, Mysore.

No. 4. White impure kaolin, subjected to levigation before analysis ; from Shillong, Khasi and Jaintia Hills.

No. 5. Prepared grey clay from Bagirghat, Bengal ; a good example of a terra-cotta clay.

No. 6. Dark brown clay with red and yellow ochre in large specks ; from Hanthawaddy, Burma.

Of the clays represented by the above analyses, No. 1 is reported to be suitable for the manufacture of good quality earthenware or porcelain ; No. 2 for the same purpose after careful preparation ; No. 3 is highly refractory and suited for the manufacture of fire-brick or earthenware ; No. 4 would be suitable for fire-bricks or to reduce shrinkage when mixed with kaolin ; Nos. 5 and 6 are suited for the manufacture of terra-cotta ware.

Imports.

The imports of materials coming under this section,—namely, earthenware and porcelain, earthenware piping, bricks and tiles, and clay,—are shown in table 112, from which it will be seen that there has been an increase, during the period under review, from £235,008 in 1903-04 to £365,917 in 1907-08, with an average annual value of £297,606. As the average value of the exports and re-exports of clay and clay products during the period has amounted only to £30,606, the total Indian consumption of such products exceeds the internal production by £267,000, indicating considerable scope for the development in the country of industries making use of clay.

TABLE 112.—*Value of Imports into India of Clay and Clay Products during the years 1903-04 to 1907-08.*

YEAR.	Earthenware and porcelain.	Earthenware piping.	Bricks and tiles.	Clay.	**TOTAL annual imports.**
	£	£	£	£	£
1903-04	186,669	7,627	34,441	6,271	**235,008**
1904-05	195,454	8,858	39,590	4,834	**248,736**
1905-06	224,052	14,454	50,238	6,419	**295,163**
1906-07	259,988	5,809	70,971	6,437	**343,205**
1907-08	281,476	6,492	71,964	5,985	**365,917**
Average .	*229,528*	*8,648*	*53,441*	*5,989*	*297,606*

Cobalt.

Cobaltite, a sulph-arsenide of cobalt, and danaite, a cobaltiferous arsenopyrite, have been found as minute crystals in the slates of the Aravalli series at Khetri[1] and other places in Rajputana. These ores have been used for the manufacture of various sulphates. The minerals were formerly separated for the production of *sehta*, which is used by the Indian jewellers for producing a cobalt-blue

[1] *Rec. Geol. Surv. Ind.*, XIV, pp. 190-196, (1887).

enamel. The sulphide of cobalt, linnæite (Co_3S_4), has been recently identified in the Geological Survey Laboratory amongst some ores of copper sent from Sikkim by Colonel Newcomen. Some years ago specimens of a matte containing 11 per cent. to 14 per cent. of cobalt, the rest being iron and sulphur, were received in the Geological Survey Office, but no details as to the mode of occurrence have ever been received.[1] Small quantities of cobalt and nickel are frequently detected in the Indian manganese-ores. The best sample is the cobaltiferous wad of Olatura in the Kalahandi State, a specimen of which yielded 0·82 per cent. of cobalt oxide (CoO).

Copper.

Copper was formerly smelted in considerable quantities in Southern India, in Rajputana, and at various places along the outer Himalayas in which a persistent belt of killas-like rock is known to be copper-bearing in numerous places, as in Kulu, Garhwal, Nepal, Sikkim and Bhutan. In Chota Nagpur several attempts have been made to work lodes reputed to be rich in the metal, but in all such attempts the ore has been smelted for the metal alone, and no effort has been made hitherto to utilise the accompanying sulphur as a bye-product. At Baraganda in the Giridih sub-division of Hazaribagh, a low-grade ore-body of about 14 feet in thickness has been prospected by shafts to a depth of 330 feet, and an unsuccessful attempt was made some years ago to work the ore.

Singhbhum.

In the Singhbhum district of Bengal a copper-bearing belt marked out by old copper workings persists for a distance of some 80 miles, stretching from Duarparam on the Bamini River in the Kera Estate, in an easterly direction through the Kharsawan and Saraikala States into Dhalbhum, where the strike of the belt curves round to south-east, running through the Rajdoha and Matigara properties of the Rajdoha Mining Company, Ltd., to Bhairagora at the extreme south-east end.

The copper-ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists; sometimes the ore is collected into fairly well defined bands, but very frequently it occurs in the form of grains disseminated through a considerable thickness of schists so sparsely as to be unworkable; whereas, if the same amount

[1] E. J. Jones, *Rec. Geol. Surv. Ind.*, XXII, p. 172, (1889).

of copper minerals had been concentrated into smaller thickness of schists, workable deposits of ore would have been formed. When concentrated into definite lodes, as at Matigara, the ore may be of fairly high grade, and well worth working if it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore.

These copper-ores have been the subject of exploitation on European lines by various companies during the past fifty years, always with disastrous results, in some cases due to the poor character of the deposit attacked, and in others to the unwise expenditure of a limited capital on expensive plant before the deposit had been proved. Such results caused business and mining men to avoid the Singhbhum copper and consequently, in the absence of private enterprise, the Geological Survey of India, during the years 1906 to 1908, carried out a series of diamond-drilling operations on the belt. This directed attention to the problem, and the Cape Copper Company, having secured an option from the Rajdoha Mining Company, has been carrying on development work in the Gladstone Shaft at Matigara, supplemented by diamond-drill bore-holes along the strike of the lode. The results have been somewhat encouraging; but, until a considerably larger amount of drilling and underground development has been accomplished, it will not be possible to speak with certainty of the prospects of this mine.

As seen at the outcrops the Singhbhum lodes seem to be very poor indeed where they have not been removed by the ancients. Typically they consist of a small thickness of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small quantity of copper, possibly as red oxide, with sometimes small encrustations of liebethenite. In depth, as seen in the diamond drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite. The other minerals noticed above are evidently the outcrop alteration products of the yellow sulphide. Judging from small specimens found on the dump-heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably been deposited in their position as rather indefinite lodes following the bedding of the schists, subsequent to the arrival of the schists in their present

position. The schists with which the copper lodes are associated are chiefly varieties of muscovite and chlorite-quartz-schists, with quartzite layers. Apatite and tourmaline are also common minerals in these schists.

The information obtained in the borings put down by the Geological Survey is shown in table 113.[1] These results show that, generally speaking, the ores of Singhbhum are of low grade, and on the whole just below what is likely to be payable, except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. copper found at Laukisra, should, however, lead to the further testing of this occurrence by private enterprise. The 3-inch layer of ore giving 12·81 per cent. copper found at 736 feet in the Matigara hole is also of considerable interest, because this band happens to be identical in its mineral peculiarities with a persistent band of chalcopyrite, with blebs of quartz, ranging from 6 inches to 2 feet in thickness and found in the Matigara mine at a depth of 228 feet. It may so happen that at the depth of 736 feet the drill passed through a very thin portion of this characteristic band of ore, which is typically very variable in thickness. The encouraging feature is that this hole indicates the persistence of this band of rich ore from the depth of 228 feet to that of 736 feet. The Geological Survey drills have been lent to the Cape Copper Company, which is now further testing the Matigara lodes. This Company employed on the mine a daily average of 260 persons in 1907 and 222 in 1908.

Sleemanabad.

During the period under review considerable attention has been devoted to the prospecting and opening up of a series of copper lodes near Sleemanabad in the Jubbulpore district, Central Provinces. These lodes run in a N.N.W. direction through dolomites of Dharwar age and carry barytes, galena and pyrite, in addition to copper minerals (chalcopyrite, tetrahedrite, malachite and azurite). The selected ores are often very rich in silver (up to nearly 200 ozs. per ton) with a very variable amount of gold (*nil* to 15 dwts.). There are associated quartz-porphyry dykes carrying fluorite.[2] The lodes were first opened up by Mr. P. C. Dutt of Jubbulpore, who was subsequently joined by Messrs. Burn & Co. A considerable amount of trenching and digging of pits, with a certain amount

[1] *Rec. Geol. Surv. Ind.*, XXXVII, p. 29, (1908); XXXVIII, p. 37, (1909)
[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 62, (1906).

of underground work was carried out, aided by numerous diamond-drill holes to depths varying from 60 to 426 feet. The results obtained have been very unsatisfactory, and work has ceased for the present.

TABLE 113.—*Results of Diamond-drill Boring on the Singhbhum Copper Lodes.*

No. of bore-hole.	Locality.	Total depth of hole.	Depth of lode or cupriferous zone.	Actual thickness of lode assayed.	% of copper.
1	Kodomdiha . .	..	392′—404′	8 feet . . .	5·10
2	Do. . .	10,93′	1,069′	1 foot . . .	1·82
3	Galudih (Regadih) .	430′	131′—294′ 293′	13 inches . .	0·61
4	Landup (Nadup) .	465′	197′—198′	14 inches . .	3·33
5	Matigara . .	837′	693′—697′	3 feet 2 inches .	2·00
			697′—761′ 8″	3 feet 8 inches .	1·29
			733′ 5″—736′ 1″	2 feet 1 inch . .	1·01
			736′ 1″—736′ 5″	3 inches . .	12·81
			736′ 5″—739′	2 feet . . .	0·42
6	Laukisrá . .	392′	150′—168′	16 feet 10 inches .	2·65
			169′—171′	1 foot 10 inches .	2·13
			179′—184′	4 feet 8 inches .	1·37

The net results of the work are that 10 tons 189 lbs. of ore containing 8·36 per cent. of copper, 1 dwt. of gold per ton, and 35·175 ozs. of silver were sold in London in 1904 for a total of £73-3-11, or £7-5-2 per ton; whilst a quantity of ore, estimated at 109 tons, ranging from less than 1 per cent. to nearly 7 per cent., and averaging 1·52 per cent. of copper, is lying on the surface at the mines.

With reference to copper in the Himalaya, attention may be drawn to a note on a copper deposit near Komai, Darjeeling district,[1] and to one on the copper of Garhwal and Kumaon.[2]

Himalayas.

Recent work has also proved the existence of valuable lodes in Sikkim, where the copper is associated with bismuth, antimony and tellurium, one of the minerals discovered being the rare mineral tetradymite, Bi_2Te_3. Another mineral recently identified by Mr. Blyth in the Geological Survey Laboratory is linnæite, a sulphide of cobalt, Co_3S_4.

Sikkim.

Prospecting licenses and mining leases have recently been secured by Messrs. Burn & Co. in the copper-bearing areas in Sikkim where prospecting operations were conducted during 1907 and 1908 by Messrs. C. Wilkinson and C. E. Simmonds.

The following notes are obtained from a report made in October 1908 by Mr. C. Wilkinson, showing the principal results obtained up to that date[3]:—

At Bhotang, 44 miles from Siliguri on the road to Gangtok, some old workings were examined and two parallel lodes of pyrrhotite were opened up and found to contain varying quantities of zinc blende, galena and chalcopyrite, but the lodes are considerably faulted and disturbed, increasing the difficulty of prospecting operations which have not been developed sufficiently to prove the probable value of the occurrence.

At Dikchu, about 7 miles to the north of Gangtok and within a mile of the Gangtok-Lachen road, a distance of 75 miles from Siliguri, a better defined copper-lode was found. It was found, by opening up the outcrops for a length of 200 feet along the bed of the Sehchu, that the lode had an average width of 3 feet bearing 6·14 per cent. of copper. By cutting the vein at a greater depth with an adit it was found that for 80 feet on an average width of 40 inches the lode contained an average content of 6·8 per cent. of copper.

In the Rhotak Colah, a tributary of the Great Ranjit river, 13 miles by pack road from Darjeeling, there are extensive old workings which have been almost obliterated by landslips. Five samples of

1 H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXI, p. 1, (1904).
2 J. Coggin Brown, *Rec. Geol. Surv. Ind.*, XXXV, p. 35, (1907).
3 Published with the kind consent, through Mr. A. Whyte, of Messrs. Burn & Co.

the lode, taken at irregular intervals along a length of 500 feet. give an average of 5·6 per cent. of copper.

At Sirbong, about 1 mile north-east of the junction of the Rhotak and Khani Colahs, a lode of pyrrhotite containing chalcopyrite was exposed yielding, for an average thickness of 2 feet 6 inches, 6·45 per cent. of copper, the sampling being continued for about 100 feet along the outcrop.

The Pachikhani mine, which is reputed among the natives to be one of the richest of the mines in Sikkim, has been overwhelmed by a landslip, and has not yet been sufficiently opened for further examination (see Mr. Bose's remarks on this mine).

Another deposit was found near Pachikhani on the road from Rungpo to Pakyong, about 7 miles from the former locality. It was found that the chalcopyrite, concentrated within a zone of mica-schist about 4 feet wide, yielded on an average 4 per cent. of copper, and it is proposed to test the occurrence more fully by diamond drilling.

Within 200 yards of the bridge crossing the Rungpo on the road from Rungpo to Rhenock, and about a mile to the north-east of the second of the two Pachikhani mines, there was found a quartzose vein following the schist-planes of the Daling series and containing 3·97 per cent. of copper for an average thickness of 1 foot; it is considered that this ore can be readily concentrated by hand picking.

In the neighbourhood of Pakyong in the Pachi Colah valley, two veins were found outcropping at right angles to the stream and at a distance of 200 yards from each other. The average analysis of the samples collected from one of these lodes gave the following results:—

Copper	3·30
Iron	11·23
Lead	10·10
Zinc	2·50
Sulphur	11·68
Silica	40·10

The other lode, consisting mainly of galena, varied in thickness from 6 inches to 2 feet, and contained an average of 21·12 per cent. of lead with 5·9 per cent. of zinc.

The following ores of copper have been observed in Sikkim:— chalcopyrite, azurite, malachite, bornite, and the black oxide.

Native copper is found in leaves and small dendrites under the gossan of some of the lodes, for example, that near Bhotang. It has also been found in the débris filling the old workings cemented by ferruginous waters as in the Bhotang mine.

Conditions bearing on mineral exploitation of Sikkim.

The principal rivers of Sikkim, the Tista and the Great Ranjit, while carrying large volumes of water, are useless as means of transport, having many rapids in their courses and being subject to sudden, violent floods. Roads for the most part are few and far between, so communication between the opposite points of their banks is often a question of making a detour of 10 or 12 miles. To work mineral deposits in this area requires transport by coolies, mules or bullock carts, where the hill roads are kept in a fair state of efficiency, as they generally are throughout the State. The roads are liable to damage during the monsoon by landslips, and consequently the suggestion to build a railway from Siliguri to Rungpo is looked upon as a costly undertaking.

Aerial cable-ways can be utilised from mine to mine, or from mine to main roads, for the purposes of exploitation. Coolie labour for transport and surface work is fairly abundant. The local people are not accustomed to underground work. but there are colonists from Nepal, who have been by caste hereditary miners for many generations.

There is at present an abundance of timber in Sikkim: in the higher regions there occur oak, beech, walnut, pine, yew and chestnut; in the lower regions sal and simul. All of these are suitable for mining timber.

Running water is abundant, and, in places, might be utilised, without much expense, for generating electric power, as, for instance, in the rapids of the Tista near Rungpo, in the Dik Chu near the junction of the Lachen and Lachung rivers.

Darjeeling district.

A prospecting license has been granted to Mr. P. N. Bose for about 12 square miles of the copper-bearing deposits of the Tista valley of the Darjeeling district, where the ores occur, under conditions similar to those in the adjoining State of Sikkim in the Daling greenstone-schists, which are probably the equivalents of the Dharwars of Peninsular India. Mr. Bose reports the occurrence of a large number of small lodes in this area, those to the east of the Tista being the only ones which are rich enough to cover the cost of the dead-

work necessary to exploit thin veins. In this part of the property assays by Mr. A. N. Bose of fair samples from veins varying from 6 inches to 2 feet in thickness gave percentages of copper up to 13·35. As the ores are also highly siliceous, flux will be required for the smelting operations. Limestone and iron-ore are obtainable in the neighbourhood, and coking coal is obtainable between the Lisu and Ramthi rivers in the same district.

A syndicate has been formed to undertake preliminary smelting operations with a 30-ton plant, commencing with the richer ores on the eastern side of the Tista river, and to push on prospecting operations by diamond-drilling. [For previous references to the copper-ores of this area see F. R. Mallet, *Mem. Geol. Surv. Ind.*, XI, (1874), Part 1; *Rec. Geol. Surv. Ind.*, XV, pp. 56-58, (1882); P. N. Bose, *Rec. Geol. Surv. Ind.*, XXIII, p. 257, (1890); H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXI, pp. 1-4, (1904).]

Burma: Northern Shan States.

Copper-ore is also found in association with the lead-zinc ores of Bawdwin, in the Northern Shan States, but not, it seems, in quantity, and the Chinese do not appear to have made any use of it. They smelted, however, a small amount of copper-ore in the vicinity of Bawdwin. The copper minerals found at Bawdwin are chalcopyrite, azurite and malachite.[1]

Baluchistan.

The occurrence of copper-ores (malachite and azurite) in association with Eocene coal-measures at a point between Ziarat and Johan in Sarawan, Baluchistan, has been recorded by Mr. Vredenburg.[2] But the ores were not seen *in situ*.

Indian consumption of copper and brass.

That there is plenty of scope for the development of copper deposits in India to satisfy the Indian demand is seen by the magnitude of the imports of copper and brass. The average annual values of these for the period under review are shown in table 114, together with the exports of Indian copper and brass wares (manufactured from imported metal, of course), and the re-exports of foreign copper and brass. From these it is seen that the average annual consumption has been £1,303,959 of copper and £48,056 of brass.

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[1] T. D. LaTouche and J. Coggin Brown, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 241, 247, 249, 256, (1909). See also *Rec. Geol. Surv. Ind.*, XXXIII, p. 342, (1906).

[2] *Rec. Geol. Surv. Ind.*, XXXVIII, p. 210, (1909).

TABLE 114.—*Average Annual Exports and Imports of Copper and Brass for the five years 1903-04 to 1907-08.*

— —	Copper.		Brass.	
	£	£	£	£
IMPORTS	..	1,374,378	..	75,450
EXPORTS—				
Of Indian merchandise . . .	27,570		6,830	
Of foreign merchandise. . .	42,478		20,561	
Of Government stores . . .	371		3	
TOTAL EXPORTS .	70,419	70,419	27,394	27,394
Indian consumption	..	1,303,959	..	48,056

Corundum.

The use of abrasives in manufacturing communities seems to be on the increase, and new forms are being put on the market yearly. Emery formerly served most requirements, until purer forms of corundum were discovered in quantity. The cheaper forms of garnet have long been used to adulterate emery, and members of the spinel family, such as hercynite, have been used inadvertently as such. During the last sixteen years carborundum, manufactured by the cheap electrical power developed in America, has come into use, the production of the United States having now reached nearly 3,000 tons a year. Artificial corundum (alundum) is also being manufactured from bauxite at Niagara, and crushed steel is being used to an increasing extent.

Natural corundum has thus many competitors in the market of abrasive materials, and as a large portion of the alumina in igneous magmas is necessarily used up during the processes of consolidation by the silica and bases present, it is theoretically unlikely that the free oxide can exist anywhere in an abundance comparable to the vast quantities of combined alumina in the earth's crust. In most cases the corundum is scattered as isolated crystals through the rock, and only the most economical devices for its separation can make mining remunerative.

In India, where the use of corundum by the old *saikalgar* (armourer) and lapidary has been known for many generations, the

requirements of the country have been met by a few comparatively rich deposits, but it is doubtful if these are worth working for export in the face of the competition referred to above in Europe and America, or will even stand against the importation of cheap abrasives.

There is still, and for many generations has been, a certain trade in Indian corundum, but the returns for production are manifestly incomplete. No workings exist of the kind that could be ordinarily described as mining, but attempts have been made at times to increase the scale of operations at Palakod and Paparapatti in the Salem district, near Hunsur in Mysore, and in South Rewah.

Production.

The occurrence near Pipra in Rewah State is at present worked by an Indian trader of Mirzapur. The production and royalty realised during the five years 1904—1908 is shown below, the rate of royalty being Rs. 3 per maund (equivalent to Rs. 81·6 per ton) in 1904 and 1905, and Rs. 3-4 in 1907 and 1908. The rate is now Rs. 3-8 per maund. No figures representing the value have been given.

TABLE 115.—*Production of Corundum in Rewah for the five years 1904 to 1908.*

YEAR.	Production.	Royalty realised.
	Tons.	Rs.
1904	36·6	2,983½
1905	52·5	4,284
1906	*Nil*	*Nil*
1907	26·7	2,459
1908	36·3	3,206

Corundum is very widely distributed throughout the Mysore State, and is said to occur in every district except Shimoga. The annual production in Mysore has been estimated as follows:—

			£
1903	24·9 tons valued at		155
1904	355·4 ..	..	„ 142
1905	136·0 ..	..	„ 229
1906	33·8 ..	..	.. 155

From 1907 onwards the Chief Inspector of Mines, Mysore, has decided to discontinue publishing statistics relating to the minor economic mineral products, owing to the impossibility of obtaining them free from obvious inaccuracies with the machinery at his command. Hence, the figures quoted above serve merely to indicate roughly the extent of the corundum industry of Mysore.

In Hyderabad territory corundum to the value of £39 was raised in 1905 and of £36 in 1907. Seven tons of corundum were raised in Madras in 1904.

Much of the corundum, which is a regular item of trade in the bazars of cities like Delhi, Agra, and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cowherds, who dispose of it through the village *bania* to the larger dealers of the great cities. Our information as to the mode of occurrence and distribution of the mineral was summarised in a special memoir published by the Geological Survey in 1898.

Khasi Hills.

Our attention has recently been directed to the occurrence of corundum (*mawshinrut*) at three localities in the Nongstoin State in the North-West Khasi Hills. The localities are too difficult of access for the exploitation of the mineral on a large scale, but it is worked in small quantities and used all over the Khasi Hills for hones.[1]

Gem varieties of corundum are treated, of course, under 'Gemstones'.

Canadian corundum.

The chief producers of corundum and emery are Canada, Tureky, and Greece, Canada supplying corundum and Turkey and Greece emery. The Canadian corundum is found in Ontario in association with nepheline-syenite like that near Kangayam in the Coimbatore district.[2] By the adoption of mechanical means for concentration it has become possible to separate corundum from the felspar-rock in which it is embedded, and to put a product on the market, not only for local use, but for export to the United States and Europe.

The Canadian industry commenced in 1900, and the annual production for the last five years has averaged 1,703 tons valued at £31,323.

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[1] F. E. Jackson, *Rec. Geol. Surv. Ind.*, XXXVI, p. 323, (1908).

[2] T. H. Holland, 'The Sivamalai series of Elæolite and Corundum-Syenites' *Mem. Geol. Surv. Ind.*, XXX, pt. 3, 1901.

Gem-stones.

The most valuable of the precious stones raised in India is undoubtedly the ruby, but this and the other stones obtained in the country do not approach in value the unset stones and pearls imported, which, during the period under review, had an average annual value of £715,974 (compared with £511,206 during the previous quinquennium).

Of the precious and semi-precious stones in India, the most important, amber, diamond, jadeite, ruby, sapphire, and spinel, have been already referred to. Of the others, the only ones that are of immediate concern are agate, rock crystal, beryl, garnet, tourmaline and turquoise. All of these except the last have been or are still being worked to some extent in India, and the turquoise may be dismissed with the mere mention of the fact that India, besides being a large importer for local use, is one of the channels by which the material raised in Persia and adjoining areas reaches the European and Eastern market. The other minerals—with some other Indian stones at present used very little or not at all—deserve more particular mention.

Agate.

There is still a considerable trade in agate and the related forms of silica, known under the general name of *hakik*, and obtained from the amygdaloidal flows of the Deccan Trap. The best known and perhaps still the most important of the places at which agate and carnelians are cut and prepared for the market is Cambay, the chief city of the State of that name under the Kaira Political Agency, Bombay Presidency. The agates come from various states and districts on or near the edge of the trap, but mostly from the State of Rajpipla. An account of the Rajpipla agate industry has been given recently by Mr. P. N. Bose.[1] The agates occur in a conglomerate of probable Pliocene age, and have been worked chiefly at Ratanpur and Damlai. The stones are chipped at the mines, and those approved of taken to Limodra, where they are baked. The baked stones are sent to Cambay for cutting and polishing. The Rajpipla *hakik* mines are leased for periods of five years at a fixed annual rental or royalty. This was Rs. 3,000 a year for the period 1902—1906. No precise data as to the value of the stones sent to Cambay are available. A certain amount of

[1] *Rec. Geol. Surv. Ind.*, XXXVII, pp. 176-182, (1908).

agate-cutting is also carried on at Jubbulpore in the Central Provinces, at Banda in the United Provinces, and at a few other places within range of the Deccan Trap.

Much of the agate retailed in Europe is sent from Cambay, and large quantities are also exported to China.

Various forms of quartz—rock-crystal, amethyst, etc.,—are used by jewellers in various parts of India.

Rock-crystal

In the Tanjore district, Madras Presidency, fragments of rock-crystal are collected and cut for cheap jewellery, being known as 'Vallum diamonds,' whilst the bipyramidal quartz-crystals, found in the gypsum of the salt-marl near Kálabagh, on the Indus, are to a certain extent used for making necklaces; rock-crystal is similarly used for cheap jewellery in Kashmir. Fine pieces of rock-crystal are sometimes cut into cups, sword handles, and sacred objects, such as lingams, in Northern India.

Amethyst and rose quartz.

Small amethysts, usually of uneven colour, are obtained at many places from Deccan Trap geodes, *e.g.*, in the bed of the Narbada near Jubbulpore, and used for jewellery and beads. Amethyst is common in the Sutlej valley in Bashahr, Punjab.[1] Rose-quartz is found at several places [2] and could also be used in cheap jewellery.

Apatite.

Green apatite derived from pegmatites in Ajmer in Rajputana is sometimes cut into gem-stones, and a considerable quantity of apatite of a rich sea-green has been found at Devada, Vizagapatam district, Madras, probably from a pegmatitic variety of kodurite.[3]

Beryl.

Beryl in its pale-coloured varieties is of common occurrence in the granite-pegmatites of India, but the crystals are generally too much fissured for use as gem-stones. Occasionally in the pegmatite veins which are worked for mica in Behar and in Nellore, large crystals of beryl, many inches across, are found to include clear fragments which might be cut as aquamarines; but the only places in India where attempts have been made to excavate pegmatite solely for its aquamarines are at Padyur (Pattalai) near Kangayam, Coimbatore district, and at different places in the Toda hills in Rajputana.

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1 H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).
2 L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 212, (1909).
3 *Op. cit.*, p. 206.

Stones of considerable value were obtained from the mine which was worked at Padyur in the early part of the nineteenth century: a pit some 30-40 feet in depth is still in existence, but no one seems to have taken an interest in the place since J. M. Heath held a lease in 1818. The whole area is impregnated with igneous intrusions, and deserves more attention than it has so far received.

At Sagar near Sarwar in the Kishangarh State, Rajputana, aquamarines occur in mica-bearing pegmatites.

Chrysoberyl.

Platy crystals of this mineral have been found in the corundum-bearing felspar-veins near Kangayam in the Coimbatore district, associated with nepheline-syenites; but the crystals are too highly flawed to be suitable for gems. Yellow crystals, transparent and of good quality, are said to occur with mica and aquamarine in pegmatite veins at Govindsagar, Kishangarh State, Rajputana.

Garnet.

The only garnets worked to any considerable extent in India occur in the mica-schists of Rajmahal in Jaipur State, at Shahpura in Udaipur State, in the Sarwar district of Kishangarh State, and in the district of Ajmer-Merwara, all these localities being within a relatively small distance of each other. Returns are not available to show the condition of the industry in the Jaipur State, but the statistics obtained indicate the existence of a considerable industry in the other areas. The following returns have been received for the Shahpura output for the years 1904 to 1907:—

	Cwts.
1904	152
1905	384
1906	46
1907	74

The values returned seem unreliable, except that for 1905, which is the price realised, *viz.*, Rs. 45,548 or £3,037.

Production figures for Kishangarh are available for two years only:—

	Cwts.
1907	16
1908	294

The annual revenue derived by the Kishangarh State from the industry is stated to average Rs. 20,000 (£1,333). The Kishangarh garnets are said to be the finest in India.

More complete statistics are available for Ajmer-Merwara and are given below :—

		£
1904	139 cwts. valued at	1,350
1905	160 " " "	215
1906	166 " " "	742
1907	15 " " "	111
1908	32 " " "	168

The various values returned indicate the following average values of garnet per cwt. :—

Shahpura	Rs. 93	or £6·2 per cwt.
Kishangarh	Rs. 100	or £6·7 "
Ajmer-Merwara	Rs. 76	or £5·1 "

The garnets being worked in India belong to the almandite variety, and have a purple colour. Stones of large size are obtained and their cutting for the market forms an important industry in Jaipur and Delhi.

Gem garnets are also found in other parts of India, as in the Tinnevelli district, Madras,[1] and used locally. Attention may also be drawn to the fact that the manganese garnet, spessartite, so characteristic of the gonditic rocks of the Central Provinces, is in America sometimes used as a gem. The Indian variety varies from a beautiful bright orange to red-brown, but has not yet been found sufficiently free from flaws to be of use as a gem.[2]

Iolite.

Cordierite or iolite, a mineral exhibiting striking pleochroism, is found in the gem gravels of Ceylon and cut as a gem under the name of lynx-sapphire and water-sapphire. A polished and roughly engraved piece of iolite found in some excavations at Budh Gaya, and showing strong pleochroism, deep violet to nearly colourless, has long been in the Indian Museum, but no locality for the mineral was known.[3] It has now been found at two localities, namely, in complex rocks composed of sillimanite, hypersthene and biotite, in the Vizagapatam Hill-tracts,[4] and in the Kadavur Zemindari, Trichinopoly district, Madras, where Mr. Bose reports its occurrence in abundance near Udaiyapatti and Kiranur, associated with labradorite and mica-schist. There are ancient pits, dug apparently for this mineral.

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[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234, (1906).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 604, (1909).
[3] V. Ball, *Proc. As. Soc. Beng.*, 1881, p. 89.
[4] T. L. Walker, *Rec. Geol. Surv. Ind.*, XXXVI, p. 13, (1908).

Kyanite. Kyanite is found at many localities in the Archæan formations of India and is occasionally used as a gem-stone on account of the fine blue colour it sometimes displays.[1] An authenticated locality for gem kyanite is Narnaul, Patiala State. The jewellers at Patiala call it *bruj*, and say that it sells at Rs. 3 to Rs. 5 per tola, equivalent to 10*s*. to 16*s*. 8*d*. per ounce.[2] Kyanite is also plentiful in Kanaur and Bashahr in the Punjab Himalayas,[3] where it has often been mistaken for sapphire.

Rhodonite. Rhodonite, a manganese-pyroxene, is used abroad (*e.g.*, in the Urals) as a gem and cut into all kinds of ornamental objects. It is found at many localities in India associated with manganese-ore deposits; and although none of it has yet been used for ornamental purposes, suitable material for the manufacture of small objects could be obtained at several of the mines.[4]

Tourmaline. The beautiful red tourmaline, known as rubellite, is worked on a small scale in the Ruby Mines District of Upper Burma. The production for the four years 1904 to 1907 is shown below; figures for 1908 could not be obtained:—

1904	29 lbs. valued at	206
1905	161 " " "	1,501
1906	193 " " "	1,001
1907	20 " " "	293

An interesting report was published in 1908 by Mr. E. C. S. George, Deputy Commissioner of the district,[5] on the workings for tourmaline round the small Palaung hamlet of Sanka about a mile east of Maingnin, where operations were carried on by the Chinese, according to local tradition, some 150 or 200 years ago. Mr. George states that after the Chinese deserted the area, the Kachins re-opened the mines about forty years ago, but the industry was again interrupted until about 1885, when more systematic operations were commenced under Pu Seinda, who contracted to conduct

1 M. Bauer and L. J. Spencer, 'Precious Stones,' p. 415, (1904).
2 P. N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59, (1906).
3 H. H. Hayden, *Mem. Geol. Surv. Ind.* XXXVI, p. 102, (1904).
4 L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 144, 604, (1909).
5 *Rec. Geol. Surv. Ind.*, XXXVI, pp. 233-238.

all mining operations until 1895. The Möng-mit (Monieit) stone-tract was afterwards notified by Government and regular licenses were taken up in 1899. During the years 1903 to 1905 the amounts recovered from 'tourmaline licenses,' the rate being Rs. 2 per worker per month, have been Rs. 2,000 (£133) to Rs. 3,000 (£200) each year; since then they must have fallen off.

The tourmaline is found in soft, decomposed granite-veins, which, being generally covered by a thick deposit of jungle-clad soil, are found rather by accident than through the guidance of any superficial indications. Isolated crystals are found occasionally lying in the red soil, and men with small means sometimes find it profitable, when they have leisure, to search through the soil-cap by digging shallow pits. *Twinlons* or vertical shafts, about 4 or 5 feet square, are also put down on the chance of striking a tourmaline-bearing vein, or *kyaw*, and the owners of these *twinlons* are permitted to extend their workings underground to a radius of five fathoms from the centre of each shaft. Some of the workings extend to depths of about 100 feet, which appears to be about the limit of the miners' engineering skill. The tourmaline found is sorted into three classes: (1) *ahtet yay*, the best light-pink rubellite, of which there are two kinds, *hteik ti*, showing well-developed basal planes, and *be yan*, crystals terminated by rhombohedral faces, or with only a small development of the basal plane; (2) *akka*, of a darker colour with the lower part of the crystals brown or black in colour; (3) *sinzi* or *arnyi*, all fragmentary crystals of any colour which are imperfect, or of a small size, less than about an inch. The *sinzi* is given without charge to the buyer of the lots of the two better kinds. The best kind, *ahtet yay*, may bring as much as Rs. 1,200 to Rs. 1,500 a viss (3·65 lbs.). The *myaw* system, or exposure of the veins on the hill-side by hydraulic action, has also been attempted at two localities with uncertain results: this work is limited to the rains and is handicapped by the cost of leading the water-channels for long distances. All locally made purchases are effected by brokers, usually Shans or Shan Burmans. They in turn sell at Mandalay to purchasers for the Chinese market.

In 1908 there was an output of 1 viss 40 ticals or 5·1 lbs. worth £36 from the Möng-mit State; whilst in the Northern Shan States 32 stones weighing 159·7 ratis or 94·5 carat,[1] valued

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[1] At 1 rati = 1¾ grains troy = ·592 carat.

at £289, were found in a conglomerate in the valley of the Nampai, north-west of Mönglong in Hsipaw State.

A beautiful green tourmaline with a crystalline limestone matrix is worked in a small way at Namon near the Salween river in the Southern Shan States. Green and blue varieties occur in the pegmatites of some parts of the mica-mining area of Hazaribagh district, but the stones are not worth the cost of extraction.

Green tourmalines are also found at the Sapphire Mines area of Zanskar in Kashmir.

Zircon.

The mineral zircon is known in various parts of India, and where it occurs in the nepheline-syenite series near Kangayam in the Coimbatore district it is picked up in small quantities and passed into the market as corundum; but it is nowhere found sufficiently transparent and flawless to be used as a gem.

Glass-Making Materials.

The common, impure sands of the rivers and the efflorescent alkali salts, so common in many parts of India, are used in various places for the manufacture of the inferior varieties of glass used for bangles.

The chief difficulty in the way of manufacturing the better grades of glass in India is the absence of known deposits of quartz-sand of the requisite purity and of suitable texture. In a few places, however, attempts are being made to introduce European methods and to make a better class of article. The factory at Rajpur near Dehra Dun, known as the Himalaya Glass Works, started work in 1903, and was on the road to success, but the Company was wound up in 1907 owing to mismanagement. In 1909 the factory was purchased by four Indian gentlemen, and is now working again. The sand used is obtained by crushing a local friable sandstone, limestone is obtained in the hills near the works, soda is imported and coal brought from Bengal.

The sands found at various localities in the Rajmahal Hills and reported to be suitable for glass-making, have been investigated recently by Mr. Murray Stuart.[1] He concludes that the sand met with in this area is generally unsuitable for the manufacture of any but the commonest kinds of bottles. The sands considered occur as (1) recent river-sands, and (2) Damuda (Gondwana) sandstone.

[1] *Rec. Geol. Surv. Ind.*, XXXVII, pp. 191-198, (1908).

To what extent a glass-making industry would find a market in India may be judged by the fact that during the past ten years the annual imports of glass and glassware have gradually risen in value from £440,000 to over £900,000 in 1907, with a fall to a little over £800,000 in 1908. The chief items in this total are bangles, beads and false pearls, common bottles and lampware.

Gypsum.

Gypsum occurs in considerable abundance in various parts of India, occurring both in the fibrous form and as clear selenite crystals. In Baluchistan, the Tertiary clays and shales of all ages, whenever they are but slightly disturbed, contain numerous crystals of gypsum scattered throughout their mass;[1] in Sind it occurs in beds sometimes 3 to 4 feet thick near the top of the Gaj beds of the Khirthar range; in Cutch it occurs in abundance in the rocks below the Nummulitic limestones; in the Salt Range it occurs in large masses with the salt marl, lying below Cambrian beds.

A very interesting and, judging by the returns, important occurrence is N.W.W. of Nagore in Jodhpur, Rajputana, where a bed, 5 feet thick or more, occurs in silt probably formed in an old salt-lake. The output during the five years 1904 to 1908 is returned as follows, the average annual figures being 4,837 tons valued at £161 (at a uniform rate of 8 annas per ton):—

			£
1904	3,875	tons valued at	129
1905	4,800	,, ,, ,,	160
1906	3,600	,, ,, ,,	120
1907	5,650	,, ,, ,,	188
1908	6,260	,, ,, ,,	209

Selenite crystals of similar origin to that of Nagore have been recently found in the kankar near the base of the silt in the Sambhar lake, and are also obtained at Pachbadra during the manufacture of salt from brine.[2]

New occurrences of gypsum have been discovered in the Vindhyan series at Satna in Rewah State[3] (probably of no economic value);

[1] E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 209, (1909).
[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXII, p. 231, (1905).
[3] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 233, (1906).

in the Kangra Chhu in Bhutan,[1] in association with dolomites; and in the Hamirpur district, United Provinces,[2] in limited quantities in the older alluvium. Gypsum is also found in Spiti and Kanaur, in the Punjab Himalayas. Between the Lipak and Yulang rivers in Kanaur the gypsum occurs in immense masses and thick beds replacing Carboniferous limestone; it is used locally for whitewash, but the inaccessibility of the deposits would render abortive any attempt to mine the mineral for transmission to the Indian markets.[3]

Lead, Silver, and Zinc.

Galena, the sulphide of *lead*, occurs in a large number of places in India and Burma, and is often *argentiferous*. The oxide and carbonate of lead are also commonly found in parts of Chota Nagpur and the Santal Parganas of Bengal. Formerly the mineral was worked on a small scale; but the industry gave way before the cheaply imported metal. But with the increasing demand for lead attention is being directed to the Indian and Burmese occurrences. As far as is at present known ores of *zinc* are not at all common in the Indian Empire; they have been found associated with the antimony-ores of Shigri in Lahaul, with the silver-lead ores of Bawdwin in the Northern Shan States, and with the copper-ores of Sikkim. No successful attempts to extract the metal have yet been made by Europeans, but up till about a century ago zinc was extracted from carbonate of zinc (smithsonite) at Jawar or Zawar in Udepur State, Rajputana.

Bengal: Manbhum.

In 1904 and 1905 Messrs. Mackinnon, Mackenzie & Co. of Calcutta opened up a deposit of galena and quartz in mica-schist at Beldi in the Birbhum Estate in the Manbhum district, Bengal. The deposit turned out to be a surface pocket, and gave out at a small depth. All the ore visible was extracted and railed to Howrah, and smelted in a small furnace that had been erected for the purpose at Shalimar near Calcutta. The total amount of ore smelted was:—

(*a*) 120 tons of galena containing about 50 per cent. of silver-lead.

1 G. E. Pilgrim, *Rec. Geol. Surv. Ind.*, XXXIV, p. 28, (1906).
2 T. D. LaTouche, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 281-285, (1909).
3 H. H. Hayden, *Mem., Geol. Surv. Ind.*, XXXVI, p. 101, (1904).

(*b*) 147 tons of rubble and quartz containing about 25 per cent. of silver-lead.

The total yield from this was 92 tons 16 cwts. 1 qr. 7 lbs. of silver-lead, which was sold in London, the yield from it being :—

86·04 grains of gold.
4,716·15 ozs. of silver.
91 tons 9 cwt. 1 qr. 13 lbs. of lead.

The proceeds of the sale just met the total expenses of the mining, smelting, etc. Eight other localities—Janijhore, Kushboni, Lataparah, Lewshai, Parada, Ghagra, Nannah, and Dekia—in the same district were also thoroughly prospected. All the occurrences were in mica-schist, and proved to be barren in depth, and no true continuous lode was found.[1]

Bengal: Sikkim.

In Sikkim lead is found in the form of galena at Pachi Colah, and enters into the composition of certain characteristic mixed sulphide lodes, as at Bhotang, Pachi Colah, and some other places; whilst zinc is found associated with some of the copper-ores in the form of calamine, and is nearly always associated with pyrrhotite and pyrite lodes in the form of blende.[2]

Burma: Bawdwin.

The portion of the Indian Empire in which there seems to be the greatest chance of finding payable metalliferous veins is the mountainous eastern part of Upper Burma. The existence of the ancient silver-lead mines of Bawdwin-gyi in Tawngpeng, one of the lesser Northern Shan States, has long been vaguely known. They were worked by Chinese from Yunnan for a very long period until about fifty years ago, when they were deserted. Traces of the Chinese activity are everywhere apparent, notably in the numerous galleries driven into the hill-side for the extraction of the ore, and in the enormous heaps of zinc-lead slag that were thrown away after smelting out a portion of the lead with the bulk of the silver. A concession over this area was taken up by the Great Eastern Mining Company, Ltd., in about 1902, the old workings were partially re-opened, and a light railway commenced to connect the mines with Manhpwi station a few miles above

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[1] We are indebted to Sir D. M. Hamilton for this information.
[2] From the report by C. Wilkinson—see p. 238.

Hsipaw on the Shan States branch of the Burma Railways, a distance of some 40 miles through mountainous country. The property was eventually sold to the Burma Mines, Railway and Smelting Company, Ltd., now the Burma Mines, Ltd., and the railway has been recently completed. The present project is to smelt the slags for the recovery of the lead, and smelters have been erected for the purpose at Mandalay, whither the ore can now be railed.

Up till the end of 1908, practically the whole of the capital and energy of this Company was devoted to the completion of the railway mentioned above, so that no smelting was carried out. During the year 1909,[1] however, 11,850 tons of lead slag lying on the surface at the mines, and 485 tons of ore obtained from open-cut workings, were transported to the Mandalay smelters and treated for a return of 5,030 tons of lead and 27,500 ozs. of silver. The whole of this metal was shipped to London for refinement and sale, where it realised the sum of £68,100. At present only two small furnaces are in operation with a total smelting capacity of from 80 to 100 tons of ore or slag per day, but a larger furnace is in course of erection, which will bring up the total capacity of the plant to about 200 tons per day.

The amount of slag available is estimated at from 110,000 to 125,000 tons. Average samples of the slag indicate—

48 to 49 per cent. of lead.

17 to 18 per cent. of zinc.

$1\frac{3}{4}$ to $2\frac{1}{2}$ ozs. of silver per ton of lead, with traces of gold.

The original ore probably carried upwards of 80 ozs. of silver.

The Chinese worked only those portions of the deposits lying above water level: it is proposed later on to explore, and, if it be worth while, to mine, those portions lying below water level, and a site is being selected for sinking a fair-sized prospecting shaft in order to test in depth the ground under the rich surface deposits.

A paper dealing with the geology and mineralogy of these deposits in Bawdwin by Messrs. T. D. LaTouche and J. Coggin Brown has been recently published.[2] The ores occur in a zone of intense disturbance, caused by one or more great overthrust faults traversing the rocks, which are felspathic grits and rhyolitic tuffs, probably

1 Information kindly supplied by the Resident Manager of the Burma Mines, Ltd.

2 *Rec. Geol. Surv. Ind.*, XXXVII, pp. 235-262, (1909).

of Cambrian age. They consist for the most part of argentiferous galena and zinc-blende, with a small quantity of copper pyrites in minute granules. The other minerals found are anglesite, cerussite, barytes, pyrite, malachite, azurite and smithsonite (zinc carbonate). The deposition of the ores has been accomplished by the metasomatic replacement of the felspar and other rock-forming minerals present.

Argentiferous galena is worked by Shans in two States in the Myelat division of the Southern Shan States. These are Mawsön (Bawzaing) and the Kyauktat sub-State of Yaunghwe. The combined output in 1908 was 63½ tons valued at £79.

Burma: Mount Pima.

In the foothills of Mount Pima, Yamethin district, 16 miles north-east of Pyawbwe, a lode of argentiferous galena, from 3 to 30 feet thick, has been traced for a distance of about a mile and a quarter along the strike, the 'country' being limestone; there are also indications of copper, both carbonate and sulphide, on the property. The Mount Pima Mining Company, Ltd., with a capital of Rs. 20,00,000, of which Rs. 11,00,000 has been issued, was formed in 1908 to work this property, and has been granted a concession of 10 square miles on prospecting license. A dressing plant for the treatment of 100 tons of ore per day is being erected at Pyawbwe on the Burma Railway. The mines at Mount Pima are connected with this concentrating plant by a private railway of 2′ 6″ gauge, 16 miles long. The concentrates are for the present to be shipped to Europe, but it is possible that the Burma Mines, Ltd., will smelt for the Company at their Mandalay smelting works.[1]

Central Provinces; Sleemanabad.

Some of the metalliferous lodes at Sleemanabad in the Jubbulpore district, Central Provinces, carry galena. Both this and the tetrahedrite, especially the latter, are sometimes very rich in silver (up to 200 ozs.), but as already noted the development of these lodes has been stopped for the present (see page 237).

Punjab and Baluchistan.

In the Punjab, galena has been found in a small quartz vein in the Upper Triassic limestones in the hills between Po and Dankhar in Spiti; the small isolated cubes are extracted by the local *shikaris*

[1] Information kindly supplied by Messrs. J. A. Begbie & Co., of Rangoon, the Managing Agents.

for the manufacture of bullets,[1] whilst both galena and blende, the former argentiferous, occur at the stibnite locality, Shigri in Lahaul. The old lead mines of Shekran, near Khozdar in Jhalawan, Baluchistan, have been re-visited, and the mines, which are no longer worked, found to occur in liassic limestones. The chief ore is cerussite; silver has not been detected.[2]

Consumption of lead.

The extent of the market in India for lead is indicated by the import figures. During the five years 1903-04 to 1907-08 the imports of lead have averaged £136,781 annually, with an average annual export to the value of £3,987, leaving a net internal consumption of lead to the value of £132,794 a year. These imports consist largely of sheet lead for tea chests; of a smaller proportion of lead sheets, pipes and tubes, and of pig lead; and of a still smaller proportion of ore.

Consumption of silver.

Although India is not a producer of silver, except for the small quantity that is now being smelted in the Shan States, it is the largest consumer in the world, and is commonly referred to as the "sink" for silver; the extent of the Indian consumption is indicated by the following figures: the imports of silver treasure in the form of coinage and bullion, both as private and Government merchandise, during the five years 1904 to 1908, have averaged £13,569,790 annually, whilst the exports during the same period have been of the average annual value of £1,748,414. This leaves a net annual Indian importation of silver to the value of £11,821,376, corresponding to 94,096,738 ozs. of silver coin and bullion, equivalent to 85 to 87 millions of ounces of fine silver, according to the fineness of the silver; and of this total a large proportion is to be regarded as consumption, being hoarded by the Indians in the form of jewellery, bullion and coin.

Consumption of zinc.

There is a considerable consumption of zinc in India, imported in the form of the metal, brass, and German-silver. During the five years 1903-04 to 1907-08 the imports of zinc in the metallic form, unwrought and wrought, have averaged £132,034 per annum, and the exports £465, leaving an annual Indian consumption of £131,569.

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI. p. 102, (1904).
[2] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 215, (1909).

During the same period the imports of brass have averaged £75,450 annually, and the exports and re-exports £27,394, leaving a net annual consumption of the value of £48,056. German-silver is an alloy of copper, nickel, and zinc of varying composition (it may be taken as consisting typically of 60 per cent. of copper, and 20 per cent. of each of nickel and zinc). The imports of this alloy during the same period have averaged in value £127,447 annually.

Marble.[1]

India has long been famous for its marbles, chiefly on account of the fine buildings, such as the Taj Mahal, built from this material by the Moghals. On account of their chemical purity, the Indian marbles retain their white surface colour after, as shown by the Moghal buildings, an exposure to the weather for over 300 years.

Occurrence.

The best known occurrences of white marble are at Makrana in Jodhpur, at Kharwa in Ajmer, and at Tonkra in Kishangarh, the last-named being dolomitic marble. It is to the coarseness of their grain that these marbles owe in part their resistance to the weather; it is their purity that enables them to maintain their white surface, and it is their translucence that gives them their delicate softness, which could never be obtained from a fine-grained marble more suitable for statuary than for architectural purposes. Similar white marble occurs in unlimited quantities forming the hills of Kyaukse, Sagyin, and Mandalay on the banks of the Irrawaddy. A coarse white marble is found in Mergui; whilst a saccharoidal dolomitic marble is exposed in large quantities at the far-famed Marble Rocks, forming a beautiful gorge traversed by the Narbada river near Jubbulpore.

Homogeneous yellow marble, and also yellow and grey shell marble, is found at Jaisalmer in Rajputana. Serpentinous limestones, showing green and yellow tints, are found in Ajmer and other places along the Aravalli belt; but the most striking example of this class occurs at Motipura in the Baroda State in the form of a handsome mottled green marble. Very variegated serpentinous limestones occur also in parts of the Cuddapah and Karnul formations

[1] See T. H. Holland, *Journal of the Queen Victoria Indian Memorial Fund*, No. II, March 1904, pp. 18-26.

in the Madras Presidency, and at several localities in the Nagpur and Chhindwara districts in the Central Provinces.

Pink marbles occur in abundance in the Aravalli belt of Rajputana, and in the Narsinghpur district of the Central Provinces.

Mottled and streaked grey marbles occur in Jodhpur; dark-grey marbles are obtainable in Kishangarh and Jodhpur, while black marble has been found at Bhainslana in Jaipur.

A mottled concretionary dolomitic marble occurs in the Vindhyan series in the Gwalior State, whilst onyx marbles are found at Nurpur in the Shahpur district, and near Jhuli in the Baluchistan desert.

Imports.

In spite, however, of the existence of such large supplies of marbles of every variety in different parts of the Indian Empire, there is a large import of marble from abroad, chiefly from Italy. This is due partly to the great distances that separate the Indian marble deposits from such cities as Calcutta and Bombay, and partly to the systematic organisation of quarrying operations in Europe, so that the cost of foreign marble has been reduced. The foreign imports of stone and marble during the five years 1904 to 1908 have averaged 12,587 tons a year, valued at £26,574.[1] On account of the freight advantages attaching to the supply of European marbles, it would probably not pay to lay out much capital on Indian marble quarries; but with an order sufficiently large to warrant systematic quarrying operations, marble ought to be procurable at a cost that would repay employment in Rajputana, and possibly in Burma. The Rajputana quarries are both protected and hampered by their distance from the sea-board, but in Burma there are hills of marble standing on the banks of the Irrawaddy, and therefore well suited for water transport.

Production.

Marble is, however, quarried on a small scale at Makrana in Jodhpur, the average annual production during the period under review being 1,718 tons valued at £1,483 (see table 116). There is also a small annual production of marble in the Mandalay district for images and pillars. No figures of production are available, but the outturn was valued at £681 in 1905 and £547 in 1906.

[1] The returns available do not indicate what proportion of this total is marble.

The Victoria Memorial Hall.

It is well known that, in 1901, Lord Curzon initiated a scheme for the erection of a great national Indian memorial to Her Majesty the late Queen Victoria, and that, as the result of subscriptions from all parts of India, a sum was collected sufficient for the erection on the Maidan in Calcutta of a large building to be known as the Victoria Memorial Hall. As it was proposed that this should be a marble memorial, the question naturally arose as to whether Indian or foreign marble should be employed.

TABLE 116.—*Production of Marble in Jodhpur, Rajputana, during the years 1904 to 1908.*

YEAR.	Quantity.	Value.
	Tons.	£
1904	1,034	1,102
1905	1,726	1,840
1906	1,500	1,665
1907	2,571	1,494
1908	1,758	1,316
Average	*1,718*	*1,483*

Obviously, a much greater outlay would have been required in order to utilise the marbles of Rajputana, handicapped by heavy freight charges, than the marbles imported by sea from Italy or Greece. Nevertheless, an enquiry was undertaken by the Geological Survey into the relative merits of marbles from various parts of the Indian Empire and from Italy and Greece. The results of these tests, which are summarised in table 117, were to demonstrate the superiority of the Indian marbles over those from abroad; and in consequence of the generosity of the Jodhpur Darbar, it has been found possible to use the marbles from Makrana in Jodhpur. The Jodhpur Darbar will charge 8 annas per maund on the marble quarried for the Victoria Memorial Hall, but out of this sum they will refund 6 annas in cash per maund, as an additional subscription towards the Memorial, leaving 2 annas per maund as the

actual royalty to be paid. The East Indian, the Bombay-Baroda and Central India, and the Jodhpur-Bikaner Railway Companies have been similarly generous, and have undertaken to carry the marble required for the Hall free of charge. The quantity of marble required is estimated by the contractors at nearly 200,000 cubic feet.

Test of weathering of Indian and foreign marbles.

For the purpose of experiments referred to above, a piece of each marble to be tested was cut into a small test-piece of rectangular shape measuring $2'' \times 1'' \times \frac{1}{2}''$, the weight of the test-pieces lying usually between 30 and 40 grammes. All the edges and corners were well rounded, so as to prevent loss of weight by mechanical abrasion; in all, 27 test-pieces were prepared, and the specific gravity, porosity, and weight of each piece carefully determined. These test-pieces were placed on the roof of the Geological Survey Office in a special contrivance designed to give free access of the weather to the specimens, and yet sufficiently heavy to resist disturbance by the cyclonic storms that sometimes visit Calcutta. The test-pieces were first placed on the roof in batches at various dates between the 28th of July and the 18th of August 1905, and, except for a few breaks of about one day each when they were removed for weighing, were left on the roof until the 27th of April 1909, a total period of three years and nine months. The number of rainy days during the period August 1st, 1905, to April 27th, 1909, inclusive, was 299, with a total rainfall of 219·18 inches. This indicates the severity of the test to which the marbles were subjected.

On removal from the roof, each test-piece was carefully washed in distilled water, dried and weighed under the same conditions as before, and the loss by weathering ascertained. In table 117 the results are summarised. From this it will be seen that the range of percentage loss on 16 Indian marbles was 0·131 to 2·224 and the mean percentage loss 0·170. The range of percentage loss on 9 foreign marbles was 0·169—0·345, and the mean percentage loss 0·228. Thus, the Indian marbles exhibit a marked superiority when compared with the foreign marbles. Classified separately from the Indian marbles are two specimens of dolomitic marble from Tonkra in Kishangarh. The percentage loss on these is very much smaller, due, no doubt, to the

relatively small solubility of dolomite as compared with calcite. These tests justify the conclusion that the Indian marbles, particularly those of Makrana, Sagyin, and Tonkra, would resist the corrosive action of the climate of Calcutta better than the foreign marbles.

In determining the specific gravity and porosity of each of these samples at the beginning of these experiments, an interesting discovery was made, *viz.*, that, during a 24-hours' soaking in water, each of the specimens suffered a distinct loss in weight by solution in the water.

TABLE 117.—*Summary of the Results of Weathering and Porosity Tests of Indian, Italian, and Grecian Marbles.*

—	Number of test pieces.	PERCENTAGE LOSS BY WEATHERING.		PERCENTAGE LOSS BY SOLUTION.		POROSITY. (*a*)	
		Range.	*Average.*	Range.	*Average.*	Range.	*Average.*
Makrana, Rajputana .	10	·137—·189	*·171*	·004—·020	*·011*	·018—·048	*·030*
Sagyin, Burma . .	3	·131—·187	*·154*	·003—·007	*·006*	·019—·030	*·023*
Mergui, Burma .	3	·138—·224	*·185*	·014—·023	*·019*	·039—·062	*·060*
Average of Indian marbles	16	·131—·224	*·170*	·003—·023	*·012*	·018—·062	*·035*
Tonkra, Rajputana (dolomitic)	2	·067—·088	*·077*	·003—·021	*·012*	·030—·034	*·032*
Carrara, Italy . .	5	·169—·260	*·211*	·013—·017	*·015*	·079—·177	*·107*
Pentelikon, Greece .	2	·170—·254	*·212*	·013—·017	*·015*	·073—·075	*·074*
Skyros, Greece . .	1	·345	*·345*	·021	*·021*	·078	*·078*
Sicily . .	1	·222	*·222*	·013	*·013*	·074	*·074*
Average of foreign marbles	9	·169—·345	*·228*	·013—·021	*·015*	·073—·177	*·093*

(*a*) Amount of water taken up during 24 hours' soaking, expressed as a percentage of the original weight of the test-piece.

The losses thus sustained by the specimens are summarised in table 117, and again the Indian marbles show a superiority (in this case but small) over the foreign marbles, the average percentage

loss by solution in 24 hours being 0·012 in the case of 16 Indian marbles, and 0·015 in the case of the 9 foreign marbles. In the same table are summarised the figures showing the porosity of the specimens tested, the porosity being the amount of water taken up during a 24-hours' soaking in distilled water, expressed as a percentage of the original weight of the test-piece. As regards this property, the superiority of the Indian marbles is most marked, the highest value obtained for the porosity of the Indian marbles being less than the lowest value obtained for the porosity of any of the foreign marbles. The 16 Indian marbles showed an average figure for the porosity of 0·0346, whilst the average of 9 foreign marbles was 0·0928.

The smaller porosity of the Indian marbles is doubtless due to their coarser grain, permitting a less free access of water to the interior of the specimens than is the case with the Italian, Grecian and Sicilian marbles. The smaller permeability to water is doubtless also the reason of the smaller losses by solution and by weathering of the Indian marbles as compared with the foreign marbles.

Although we have compared the average Indian marbles with the average foreign marbles, overlooking the fact that, in each case, the pieces were derived from several localities, yet, if the most typical localities in each case be taken, say, Makrana for India and Carrara for the foreign marbles, and the figures for these two localities compared, it is seen that a similar superiority is shown for the Makrana marble over the Carrara marble.

Mineral Paints.

Up to the present the manufacture of mineral paints appears to be very small in proportion to the demand and the natural resources in minerals apparently suitable. In the Jubbulpore district Messrs. Olpherts & Co. of Katni are utilising the soft hematites of Jauli and are drawing supplies of yellow ochre from the Panna State, while similar works (Messrs. Turner, Morrison & Co.) near Calcutta are dependent largely on imported material. The Jauli ochre pit is held by Messrs. Olpherts & Co. on an annual rental of Rs. 800. The following production has been reported :—

	Tons.
1906	205
1907	400
1908	300

Ochres, red, yellow, and other colours, are commonly used by natives in many parts of the country, in a crude or simply levigated form under the generic name *geru*. A common source of supply is laterite in the Peninsula and Burma, but well-defined ochres occur in deposits of various geological ages down to the Archæan hematites. In the Trichinopoly district yellow ochre is obtained from the Cretaceous rocks, and in Burma large deposits are known among the Tertiary beds of the Myingyan district. It is also probable that various grades of ochre, umber and sienna could be set aside from the 'country' when working the Vizagapatam manganese-ore deposits. A black slate near Kishangarh has been successfully tried on the Rajputana-Malwa Railway. Barytes, used as a substitute or adulterant for 'white lead,' is obtainable in quantity near Alangayam in the Salem district and at Sleemanabad in the Jubbulpore district. Small amounts of barytes from the latter locality have been used by Messrs. Turner, Morrison & Co. of Calcutta (see page 218).

For remarks on the imports into Burma, and application in the arts there, of orpiment, see page 217.

Mineral Waters.

One curious feature in connection with Indian minerals is the neglect of our numerous hot and mineral springs. To what extent the value of these is purely fanciful is a matter of small concern for the time being; for whether they have the medicinal properties claimed for them or not, there is no doubt that well-advertised mineral waters have an economic value, and numerous varieties from Europe and Japan are scattered over India, and brought to the continual notice of the travelling public in all the railway refreshment rooms. Natives of India have for many ages recognised a value in mineral waters and in the hot springs, which are often charged with more than usual quantities of mineral matter. In many cases these, like most unusual natural phenomena, have become sacred to the Hindus, and have consequently become places of resort for pilgrims from great distances. Of instances of this sort may be mentioned the hot springs at Manikarn in Kulu, where the pilgrims cook their rice in the hot springs emerging in the shingle beds close to the ice-cold stream of the Parbati river. The hot water is also led into the neighbouring

temple and rest-house for baths, being supposed to be of value for rheumatism. At Lasundra in the Kaira district, and at Vajrabai in the Thana district, Bombay Presidency, springs of sulphurous water, having a temperature of 115° F., are also resorted to by Hindu pilgrims. Generally it may be said that hot springs, often sulphurous, are common throughout the Tertiary areas of Sind and Baluchistan on one side, and of Assam and Burma on the other side of India, the distribution being similar (and perhaps dependent on similar causes) to the distribution of petroleum, with its constant associates of salt and gypsum. Other springs occur along the foothills of the Himalaya, in the Kharakhpur hills, etc., sufficiently well distributed to permit of easy transport. The provincial gazetteers contain sufficient references to these springs to guide private enterprise, but more might be done in the way of analysis of the waters, which would be as interesting from a scientific as possibly from an economic point of view. The mineral water of Sitakhund in the Kharakhpur hills is the only one which has been turned to account.

Nickel.

Ores of nickel (nickeliferous pyrrhotite) have been found amongst the copper-ores of Khetri and other places in Rajputana. Nickel has also been detected in small quantities in chalcopyrite and pyrrhotite found associated with the gold-quartz reefs of Kolar, and in pyrite said to be from the Henzada district of Burma. Complex sulphide ores, consisting of pyrrhotite, pyrite, chalcopyrite and molybdenite, have been received from the Tobala taluk in South Travancore. Both nickel and cobalt are present in quantities beyond mere traces, but nothing is yet known as to the extent of the deposits, nor have any proper average samples been assayed. A surface sample of ore showed 1·20 per cent. of copper, 0·64 per cent. of nickel, and 0·08 per cent. of cobalt, with 12 grains per ton of gold and 2 dwts. 12 grs. per ton of silver. Further investigations may show that the deposits are richer than is indicated by this analysis.

There is a considerable consumption of nickel in India in the form of German-silver, the annual imports of which during the five years 1903-04 to 1907-08 have averaged 1,103 tons worth £127,447 (see page 13). Further, on the 1st August, 1907, the issue to the public was commenced of the new 1-anna nickel coinage, consisting

of an alloy of 25 parts of nickel with 75 of copper, leading to a further consumption of nickel, statistics for which are not available.

The imports of nickel received at the Bombay Mint during the two years 1907-08 and 1908-09 have totalled 7·02 tons (1,909 maunds 1,953 tolas) valued at £13,156.

Phosphates.

One regrettable feature in connection with the Indian mineral resources is the absence, in a country where agriculture is such a predominant industry, of any phosphatic deposits of value, and a further circumstance to be regretted is the export of phosphates in the form of bones, due primarily to the fact that the country being without the means for the manufacture of cheap sulphuric acid, superphosphate is not made and the small quantity used is imported from Europe. During the past five years the materials imported under the head of manures have varied in value from £4,430 in 1903-04 to £2,462 in 1907-08, whilst the exports of animal bones have averaged 82,201 tons a year valued at £318,369 (see table 118).

TABLE 118.—*Exports of Manures from India during the years 1903-04 to 1907-08.*

YEAR.	TOTAL MANURES.		ANIMAL BONES.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
1903-04	80,925	294,858	74.788	277,141
1904-05	78,068	291,856	68,203	250,097
1905-06	131,656	473,136	87,552	331,919
1906-07	164,075	676,993	93,760	369,683
1907-08	149,857	616,802	86,700	363,002
Average .	*120,916*	*470,729*	*82,201*	*318,369*

The large increase in the figures of total exports of manures for the years 1905-06 to 1907-08 is due to the inclusion of figures for fish manure and oil-cake manure.

Among the phosphatic deposits of India, the principal, and perhaps the only one worth considering, is the deposit of phosphatic nodules of the septarian kind, occurring in the Cretaceous beds of the Perambalur taluk, Trichinopoly district, Madras Presidency. Dr. H. Warth estimated in 1893 that to a depth of 200 feet the beds contained nodules to the amount of 8 million tons, but the phosphates are distributed irregularly through clay, varying, in the different excavations made, between 27 and 47 lbs. per 100 cubic feet, and in the shallow workings 70 lbs. per 100 cubic feet. Analyses of these nodules show them to contain from 56 to 59 per cent. of phosphate of lime with about 16 per cent. of carbonate. Two attempts made to dispose of these phosphates in a finely powdered condition for use as a fertilizer on coffee plantations in Southern India were, however, reported to be unprofitable, and mining leases have consequently not been applied for. A third attempt is to be made to profit by these deposits, as there is in Ceylon, according to the present concessionaire, Mr. A. Ghose, a considerable demand for the crushed nodules.

Small quantities of apatite are turned out and thrown away with the waste in the Hazaribagh and Nellore mica-mining areas, and a few other occurrences of unknown, and presumably small, value occur at different places—near Mussoorie, in Eastern Berar, and in the Eocene shales above the coal near the Dandot colliery in the Punjab Salt Range. Apatite in small granules could also be washed out of the decomposed koduritic rocks found in many of the Vizagapatam manganese mines, and might be obtainable thus in some quantity.[1] The rocks of Jothvad Hill in Narukot State, Bombay, are very rich in apatite, but hardly worth treating.[2]

Rare Minerals.

Until the issue of the previous Review (1904) the minerals of the so-called rare metals had received practically no attention in India, although some were known to exist. During the quinquennial period now under review considerable attention has been directed

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 251, (1909).
[2] *Ibid.*, p. 648.

to such minerals by prospectors, with the resultant discovery of several minerals not known previously to occur in India. One of these, wolfram, has become sufficiently important to be noticed in a separate section (see page 279). The others are noticed below.

Molybdenum.

Molybdenite, the sulphide of molybdenum, has been found in small plates in the crystalline rocks and in quartz, in various parts of Chota Nagpur, and also in an elæolite-sodalite-cancrinite pegmatite in Rajputana at Mandaoria, near Kishangarh. Molybdenite also occurs disseminated through the Travancore pyrrhotites noticed under the heading of nickel (see page 265), and might possibly be worth separating from the ores, should these ever be worked for copper and nickel.

In Burma, molybdenite has been found by Mr. Page in quartz near the 19th milestone on the road from Tavoy to Myitta. Wulfenite, the sulphide of lead, has been brought from the Karenni State in Burma, but nothing is known of its mode of occurrence.

Monazite.

During the last few years considerable attention has been devoted by prospectors to the search for monazite in various parts of India, and at last, in 1908 or early in 1909, the mineral has been found. Mr. C. W. Schomburg of Waltair representing the London Cosmopolitan Mining Company, Ltd., reports the discovery of four large deposits of this mineral, comprising in all 12 square miles of the beach sands of Travancore coast, from Cape Comorin to about 100 miles north. The concentration has been effected by the action of the waves, from detritus derived, in all probability, from the rocks of the charnockite series forming the hills separating Travancore and Tinnevelly. The quality of the sand is said to improve with depth, and excavations have shown the continuance of the mineral to a depth of 25 feet. An analysis of a small sample of some of the natural concentrates showed nearly 12 per cent. of thoria. The only other mineral in some of the samples received in the Geological Survey Office, besides monazite, is ilmenite and a small quantity of zircon. If the facts are as reported there is no doubt that a discovery of great value has been made, and we may expect the development during the next few years of another important mineral industry in India. This discovery illustrates further the similarity between the crystalline areas of Brazil and India and the economic minerals found therein; the principal minerals found

in economically valuable quantities in the two countries are diamonds, gold, mica, manganese-ore, and monazite. Further deposits of monazite sand are said to have been found to the eastward from Cape Comorin in the Tinnevelly district of Madras, by Mr. H. A. Pearson; and near Waltair in the Vizagapatam district, by Mr. Schomburg, the degree of concentration in the latter case being much less than in the Travancore sands.

From some auriferous concentrates obtained by Mr. Hayden from Chaksan on the Tsanpo in Tibet, Dr. J. M. Maclaren obtained a very small quantity of black cubical crystals of minute dimensions, which he suggested were pitchblende or uraninite. These same concentrates were subsequently examined at the Imperial Institute. The residue after removing the magnetite was found to form only 2·3 per cent. of the total, and on analysis yielded very small quantities of phosphoric oxide and oxides of cerium, thorium, and uranium, indicating 0·15 per cent. of monazite, and a trace of a thorium-uranium mineral.

Platinum and iridium.

Platinum and iridosmine have been found in the auriferous gravels of the rivers draining the slopes of the Patkoi ranges, both on the Assam and the Burma sides.

Columbite and tantalite.

Columbite (niobate of iron and manganese) and tantalite (tantalate of iron and manganese) have been found at several localities in the mica-bearing pegmatites of India. There is, of course, a perfect gradation from columbite to tantalite owing to a gradual replacement of niobium (or columbium) by tantalum, with a corresponding increase in specific gravity, and at any locality where one of these minerals has been found one may reasonably look for the other. Tantalite is of much greater value than columbite on account of the demand for tantalum for manufacturing the metallic filaments in the Tantal incandescent lamp; and, consequently, the value of samples of columbite and tantalite depends on the percentage of tantalum present, usually expressed as the oxide Ta_2O_5. These minerals have been found in the districts of Gaya (at Singar), Hazaribagh (near Kodarma), and Monghyr (at Pananoa Hill) in Bengal; in the districts of Madura, Nellore (at Chaganum), and Trichinopoly (near Vaiyampatti) in Madras; and at Masti in the Bangalore district, Mysore.[1]

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 204, (1909).

At Pananoa Hill near Jhajha (Nawadih) Railway Station, East Indian Railway, both columbite and tantalite are found, two specimens of the latter received in the Geological Survey Office having the very high specific gravities of 6·75 and 6·92. A 2-ton sample of the tantalite has been shipped to England by the concession-holder, Mr. F. H. Achard; assays have shown 37 per cent. and 52 per cent. of Ta_2O_5 on different samples.

Some years ago Mr. C. Middleton of Trichinopoly discovered, when excavating for mica in the Semmallai Hills near Vaiyampatti in the Trichinopoly district, a mineral which he had assayed in London in 1908, with the discovery that it was tantalite containing 66 per cent. of Ta_2O_5. A specimen received in the Geological Survey Office is much nearer columbite than tantalite. The occurrence is now being investigated by a local syndicate.

Titanium.

Ilmenite, or titaniferous iron-ore, occurs as small isolated crystals in various parts of the charnockite series and pyroxene-granulites of Peninsular India, but no large deposit of the ore has been recorded. It is found in abundance in the monazite beach sands of Travancore (see above). About 3 miles south of Kishangarh in Rajputana large crystals of ilmenite, 2—3 inches in diameter, are found associated with clear calcite crystals forming a broad vein in the granitoid gneiss. This ore was at one time smelted in the local native furnaces.

Rutile, one of the natural forms of titanic oxide, is widely distributed throughout many of the crystalline schists. It has been found in pieces of some size during exploratory work for mica in the neighbourhood of Ghatasher in the Narnaul district of Patiala State, Punjab.[1] Mr. Bose also reports the occurrence of this mineral in the vicinity of Kadavur in the Trichinopoly district of Madras Rutile is used for imparting an ivory-like colour to porcelain, and for the enamel of artificial teeth.

Uranium (pitchblende and samarskite).

The occurrence of the uranium-ore, pitchblende, or uraninite, with the other uranium minerals torbernite and uranium-ochre, at the Singar mica mine in the Gaya district, Bengal, and also of considerable quantities of triplite, a phosphate of iron and manganese, has been known for some years. Further specimens from this locality, brought to the Geological Survey Office in 1908 by

[1] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59, (1906).

Mr. H. A. Pearson, were found by Mr. Tipper to show in addition columbite and zircon in considerable quantities, the latter in well-formed crystals. As there are considerable quantities of these rare minerals at Singar, the occurrence should be worth exploiting for ores of uranium, zirconium, and possibly tantalum, and other rare elements, and perhaps as a source of phosphates.

A small quantity of uraninite sand, said to be from the valley of the Kistna, has been received from Mr. C. W. Schomburg.

The very rare mineral samarskite (identified by Mr. T. R. Blyth) has recently been found in a mica-bearing pegmatite near Gridalur village, Nellore district, Madras. The pegmatite is being worked for mica, but about 600 lbs. of samarskite have been collected in order to obtain an opinion regarding its value.[1] Samarskite is a very complex niobate and tantalate. chiefly of uranium, the yttrium earths, and iron.

Yttrium Earths.

Of minerals containing the yttrium earths in considerable quantity, samarskite (see above) and gadolinite have been found. The latter, which is a silicate of the yttrium earths, beryllium, and iron, occurs in a tourmaline-pegmatite, in association with cassiterite, in the Palanpur State, Bombay Presidency.[2]

Zirconium.

Zircon, or zirconium dioxide, is found in nepheline-syenites near Kangayam in the Coimbatore district, Madras, and with the triplite of Singar in Gaya (see above, page 270).

Slate.

Slate-quarrying gives a means of livelihood to numbers of workers along the outer Himalayas, where the foliated rocks, though often not true clay-slates, possess an even and perfect fissility, which enables them to be split for slabs and even fine roofing slates at Kanyara. In the Kangra district, work is being carried on in a systematic manner by the Kangra Valley Slate Company, Ltd., which during the five years ending the 31st December 1909 has declared dividends averaging 17 per cent. per annum with the addition of considerable sums to the reserve funds. The same Company works quarries in clay-slates amongst the Aravalli series near Rewari in

[1] G. H. Tipper. *Rec. Geol. Surv. Ind.*, XXXVIII, p. 242, (1910).
[2] T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXI, p. 43. (1903)

the Gurgaon district south of Delhi. Another company working in the Kangra district is the Bhargava Slate Company.

In the Kharakhpur Hills, Monghyr district, Bengal, a private company, Messrs. C. T. Ambler & Co., is working a slightly metamorphosed phyllite, probably of Dharwarian age, which, though not giving the thinnest varieties of roofing slate, produces fine slabs for which a more extended use is continually being found for flooring, roofing, ceilings, and for small dishes and curry platters for native use. Some of the quarries held by this firm date back to ancient times, and probably yielded the very fine piece of slate from which the throne of the Nawabs Nazim of Bengal, now shown in the Indian Museum, was fashioned.

Slate is also being worked in various parts of the so-called transition series of rocks of the Peninsula; such figures as are available to show the extent of the trade are given below (table 119) with the figures of production of the two companies already mentioned. The figures returned by the Nizam's Government, Hyderabad, show the annual production of a substance returned as "slabstone", varying in value from about £400 to £800 per annum but whether this "slabstone" is slate or not is not known.

TABLE 119.—*Production of Slate during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.		AVERAGE.	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bengal—												
Monghyr (*a*)	213	*2,461*	216	*2,484*	2,049	*2,623*	2,286	*2,207*	1,047	*1,509*	1,162	*2,257*
Hyderabad .	(*e*)	*378*	(*e*)	*384*	(*e*)	*472*	(*e*)	*612*	(*e*)	*768*	..	*521*
Punjab—												
Gurgaon (*b*) .	673	*673**	2,313	*2,313**	2,173	*3,584*	2,684	*1,541*	6,374	*6,503*	2,843	*2,923*
Kangra (*b*) and (*c*).	..	*4,408*	..	*2,508*	..	*4,417*	..	*5,618*	..	*4,903*	..	*4,371*
Rajputana .	30	*14*	25	*12*	186	*18*	1,011	*39*	..	..	313	(*d*) *21*
United Provinces.	4,720	*562*	4,300	*594*	6,363	*747*	6,479	*790*	6,057	*629*	5,584	*664*
	..	**8,496**	..	**8,295**	.	**11,861**	..	**10,807**	.	**14,312**	.	**10,757**

(*a*) Output by Messrs. C. T. Ambler & Co.
(*b*) Output by the Kangra Valley Slate Co.
(*c*) Weights not available; sale values given.
(*d*) Four years' average.
(*e*) Weights not available.
* Estimated.

Sodium Compounds.

Besides sodium chloride, other salts of soda, notably the sulphate (*khari*) and carbonate (*sajji*), accumulate in the soil of areas where the climate is dry, giving rise to the alkaline efflorescence known as *reh*, which renders large areas quite sterile. Both the sulphate and carbonate are also prominent amongst the sodic compounds in the brine of the Rajputana Salt Lakes. Carbonate of soda occurs in quantity in the water of the Lonar Lake referred to below.

Imports.

There was formerly a considerable production of both salts for consumption in India, but the native material is now being displaced by the cheap supplies of chemically manufactured material obtained from Europe. The total imports of soda salts have increased from about £70,000 in 1905 to £126,717 in 1908, and the increase in the imports is no doubt due in part to the gradual reduction in the cost of soda salts in centres of chemical industry. The imports of sodium bicarbonate during the period averaged 72,772 cwts., valued at £28,331. The imports of caustic soda have increased from 46,316 cwts., valued at £25,949, for the last nine months of 1905 to 92,379 cwts., valued at £55,468, for 1908.

For information concerning the alkali compounds used and manufactured in India, reference may be made to the *Agricultural Ledger*, No. 5 of 1902, published by the Reporter on Economic Products, Calcutta. Other numbers of the Ledger give information about *reh*.

Lonar Lake.

The proposal to utilise the accumulations of soda salts in the Lonar Lake (19° 59′ : 76° 33′) in the Buldana district, Berar, has been frequently raised, but the place is too inaccessible at present for anything like development on a large commercial scale. The lake lies in a depression in the Deccan Trap, and its origin, though not satisfactorily explained, is regarded as probably similar to that of the so-called 'explosion craters' of the kind described by R. D. Oldham in the Lower Chindwin district.[1] The depression is nearly circular, about a mile in diameter and 300—400 feet deep; at the bottom there is a shallow lake of saline water, which is variable in density and quantity according to the season of the

[1] *Rec. Geol. Surv. Ind.*, XXXIV, p. 137 (1906).

year. The most prominent salts in solution are the carbonate and chloride of sodium, the former being in excess and often found separated on account of supersaturation.[1]

Considerable quantities of soda salts were recovered from this lake in the old days for use in the manufacture of soap and glass; but, since the principal markets for soda are now served by the cheaper and purer products of the European chemical manufacturer, there is little demand for the impure salts from Lonar. If the lake were more accessible to the railway systems, and the operations of recovering and purifying the salts were organised in a systematic manner, Lonar might again share the greatly increasing market for soda salts.

Steatite.

One of the most widely distributed minerals in India is steatite, either in the form of a coarse potstone—so called on account of its general use in making pots, dishes, etc.—or in the more compact form suitable for carvings, and in its best form, suitable for the manufacture of gas-burners. There is a trade of undetermined value in nearly every province, but it is in most cases impossible to form even a rough estimate of its value. An exhaustive account of the Indian occurrences of steatite was published by Mr. F. R. Mallet in the *Records, Geological Survey of India*, Vol. XXII, part 2 (1889); and a note by Mr. H. H. Hayden in Vol. XXIX (page 71) of the same publication adds further details with regard to the deposits in Minbu district, Burma.

Such figures as are available for the output of Indian steatite are summarised in table 120. The values assigned to the mineral vary between very wide limits, and although this is no doubt partly due to differences in the value of the product according to the use to which it is put, yet some of the figures are probably but rough estimates, *e.g.*, in the case of Mysore.

The steatite deposits on the north side of the Marble Rocks in the Jubbulpore district, which were formerly worked by native methods with a small annual production, have now been taken up on mining lease by Messrs. P. C. Dutt and Burn & Co.; whilst deposits at Gowari and Lalpur on the south side of the Narbada have been secured by the Bombay Mining and Prospecting Syndicate.

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[1] See also the new Buldana District Gazetteer.

The output from this area in the year 1908 is returned at the considerable figure of 764 tons.

The Burmese production comes from the Minbu, Pakôkku Hill Tracts and Thayetmyo districts, and is used for pencils; hence its high value. The decreasing production is said to be due partly to the gradual replacement of the steatite pencil by pen and paper, and partly to the exhaustion of the deposits.

In 1908 Mr. A. Ghose obtained a prospecting license over the steatite deposits at Muddavaram and Musila Cheruvu near Betamcherla in the Karnul district, and during 1909 prospected the deposits at the latter place on a large scale. Samples sent to Europe and America have been favourably reported on and in one case valued at as high a rate as £10 a ton. It is proposed to export the mineral in the powdered condition, after preparation on the spot.

TABLE 120.—*Production of Steatite during the years 1904 to 1908.*

PROVINCE.	1904.		1905.		1906.		1907.		1908.	
	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Burma . . .	19	*577*	12	*341*	10	*273*	8	*201*	5	*98*
Central Provinces .	..	..	..	..	..	..	..	..	764	*1,019*
Hyderabad . .	(*a*)	*6*	(*a*)	*9*	(*a*)	*8*	(*a*)	*7*	(*a*)	*18*
Mysore . .	308	*140*	1,899	*245*	398	*98*	(*b*)	(*b*)	(*b*)	(*b*)
TOTAL .	327	*723*	1,911	*595*	408	*379*	8	*208*	769	*1,135*

(*a*) Quantity figures not returned.
(*b*) Collection of figures discontinued on account of their untrustworthy character.

Sulphur, Sulphuric Acid and Soluble Sulphates.

Sulphur.

Small quantities of sulphur are obtainable on the dying volcano of Barren Island, and on some of the volcanoes in Western Baluchistan, whilst it has been reported in connection with the petroliferous Tertiary rocks in the Baluchistan-Persian belt, as well as in the Arakan system on the east. There are, however, no deposits of free sulphur known to be worth working.

Pyrite is known in various parts of India, and in one place, near Kalabagh on the Indus, it is sufficiently abundant in the shales, which have been worked for alum (see page 209) to give rise to frequent cases of spontaneous combustion. An occurrence of this sort is one that, suitably placed, might be of value as a source of sulphur. Otherwise, the only chance of sulphur to compete with the imported article is bound up in the problem of developing the metalliferous sulphides for both metal and sulphur.

Sulphuric acid.

In view of the value of the imports of sulphur and sulphuric acid, and in consideration of the fact that a cheap supply of the acid would be the key to many industries now either non-existent or in a feeble condition, the manufacture of sulphuric acid on a large scale and cheaply would be the starting point of an economic revival.

During the five years, 1903-04 to 1907-08, the import of sulphur have averaged 63,433 cwts a year, valued at £20,516, as compared with an annual average of 34,136 cwts., valued at £12,612, for the period of the previous Review. The average annual import of sulphuric acid was 62,969 cwts., valued at £44,110, as compared with 45,374 cwts, valued at £32,273, for the period of the previous Review. Of these imports, there has been an average annual re-export of 94 cwts., largely to Persia. In addition to sulphuric acid there are several chemicals imported that could be produced more cheaply in India if the acid were made in the country in large quantities at a sufficiently low price. The average annual value of imported bleaching materials alone; during the four years 1905-06 to 1908-09, previous to which there was no separate enumeration in the trade statistics, has been £22,858, starting with £14,722 in 1905-06 and increasing rapidly to £30,388 in 1908-09.

. On the Giridih coalfield, bye-product recovery coke-ovens, with an annual production capacity of 40,000 tons of coke, have recently been erected and set into operation (in 1909).[1] The ammonia is, of course, converted into ammonium sulphate, thereby creating an additional demand for sulphuric acid; and should this experiment prove successful, as seems almost certain, several others of the coal companies will probably be stimulated to erect similar plant and prevent the great waste of bye-products now taking place in the manufacture of coke in Bengal, thus increasing the demand for

[1] T. H. Ward, *Rec. Geol. Surv. Ind.*, XXXI, pp. 92—100, (1904). T. H. Holland *ibid.*, pp. 100—102; *Trans. Inst. Geol. Inst. Ind.*, II, p. 47, (1907).

sulphuric acid. With the discovery of highly aluminous bauxites, it should now be possible to manufacture impure aluminic sulphate and alumino-ferric cake for use in the dye-works of the country. There are now several sulphuric acid factories at work in the Nilgiris (the Government Cordite Factory), near Madras (Messrs. Parry & Co.), near Calcutta (Messrs. Waldie & Co. and the Bengal Chemical and Pharmaceutical Co.), and in Cawnpore (Messrs. Waldie & Co.).

The approximate amount of sulphuric acid of all strengths manufactured by Messrs. Waldie & Co. during the period under review was about 600 to 700 tons per annum. The acid is produced by the ordinary 'chamber' process from sulphur imported from Sicily. It is concentrated to specific gravities of 1·840, 1·800, 1·710, and 1·700.

Sulphuric acid has been manufactured by the Bengal Chemical and Pharmaceutical Works, Ltd., since 1907, the raw materials used being Sicilian sulphur and Indian saltpetre. The present daily capacity of these works is about 2,500 lbs. of acid of the specific gravity of 1·740, but the works are being extended to allow of the daily production of 4,000 lbs. of acid. A small portion of the acid is used in the manufacture of nitric and hydrochloric acids; successful experiments have been carried on at these works for the manufacture of alum and ferro-alum from Katni bauxite and of bleaching powder from pyrolusite from the Central Provinces.

In the year 1908, a company entitled the Burma Chemical Industries, Ltd., with an issued capital of Rs. 2,50,000, was floated for the purpose of erecting sulphuric acid plant in or near Rangoon. The plant, consisting of four leaden chambers with Glover and Gay-Lussac towers, is designed for a daily production of 10 tons of acid of 1·84 specific gravity, from Japanese and Sicilian sulphur. The acid will be concentrated in a Kessler plant. It is to be put up in cast-iron drums. There is a considerable consumption of sulphuric acid in Burma for the refining of petroleum products. This acid has hitherto been imported from Europe, and Indian producers of sulphuric acid have not been able to supply the Burmese demand on account of the difficulty of providing lead or other suitable cases for the transport of the acid by sea from Calcutta or Madras.

Sulphates of iron and copper.

For many years pyritous deposits in India have been turned to account for the manufacture of soluble sulphates of iron and copper. The

case of alum has been referred to already (*supra*, page 208), and with the alum, which was formerly obtained in quantity from the decomposed pyritous shales at Khetri and Singhana in Rajputana, copperas and blue vitriol were also obtained. No statistics are, however, available with regard to the history of these industries, which have had to give way to the importation of cheap chemicals from Europe.

Being practically the end of the Review this is a convenient place to point the lesson taught by a general survey of progress (*cf.* page 10). Sulphuric acid is the key to most chemical and to many metallurgical industries; it is essential for the manufacture of superphosphates, the purification of mineral oils and the production of ammonium sulphate, various acids, and a host of minor products; it is a necessary link in the chain of operations involved in the manufacture of the alkalies, with which are bound up the industries of making soap, glass, paper, oils, dyes and colouring matters; and as a bye-product, it permits the remunerative smelting of ores which it would be impossible otherwise to develop. During the last hundred years the cost of a ton of sulphuric acid in England has been reduced from over £30 to under £2, and it is in consequence of the attendant revolution in the European chemical industries, aided by increased facilities for transport, that in India the manufacture of alum, copperas, blue vitriol, and the alkalies have been all but exterminated; that the export trade in nitre has been reduced instead of developed; that copper and several other metals are no longer smelted; that the country is robbed every year of over 80,000 tons of phosphatic fertilisers; and that it is compelled to pay over 20 million sterling for products obtained in Europe from minerals identical with those lying idle in India.

Although sulphuric acid and the alkalies are essential to so many other industries, the conditions for their profitable manufacture will balance the 'protective' effect of transport charges only when there is a market in the country for the bye-products which are now essential parts of the cycle of operations in a chemical industry. These conditions, as shown by the import statistics, are rapidly ripening, but the enterprising capitalist should remember, also, that the present requirements of India represent but a fraction of the consumption that will follow any material reduction in prices by local production.

Tungsten.

Occurrence.

Wolfram, a tungstate of iron and manganese, has been found in several places in the Indian Empire. In Burma,[1] placer deposits of tinstone are found in many of the streams and rivers draining down from the range of granite hills and mountains that separate Lower Burma from Siam, from the Pakchan River, bounding the Mergui district on the south, through the whole of the Tenasserim Division to a point at least as far north as the State of Karenni. Many of these placer deposits contain wolfram; but until recently this mineral had not been found *in situ* in Burma. During the last two or three years, however, Mr. J. J. A. Page has found wolfram *in situ* in quartz veins and in pegmatite (in both cases associated with cassiterite) near Maliwun and Bokpyin in Mergui; and also at various localities in the Tavoy district. Associated with some large specimens of wolframite, from the Sanchi stream in this latter district, is a small quantity of tungstite or tungstic ochre, the yellow oxide of tungsten. Dr. A. W. G. Bleeck reports the existence of a well-defined lode carrying large quantities of wolfram on the road from Thazi to Taunggyi on the border of the Yamethin district and the Southern Shan States; and also at Neyaungya in the Yengan State, Southern Shan States. A trial sample of wolfram, weighing 14 cwts., was shipped from Port Victoria in Mergui in the year 1908.

Burma.

Nagpur.

In India, wolfram has been found in the Hazaribagh district, Bengal, in the Nagpur district, Central Provinces, and in the Trichinopoly district, Madras. In Nagpur, the mineral occurs near Agargaon in a series of quartz veins intercalated in tourmaline- and mica-schists in the Dharwar system of rocks; prospecting operations are being carried out by Mr. J. Kellerschon of the Carnegie Steel Company to test the value of the deposits.[2] Small quantities of scheelite have been found associated with the wolfram.

[1] See J. J. A. Page, *Rec. Geol. Surv. Ind.*, Vol. XXXVII, pp. 39—41, (1908); XXXVIII, pp. 57—59 (1909); L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 209, (1909).

[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXVI, pp. 301 to 311, (1908).

Trichinopoly.

Mr. P. N. Bose reports the find of a specimen of wolfram near Kadavur in the Trichinopoly district, and of another near a pegmatite dyke on the eastern flanks of Ururarkarad. The former has been found to contain 31·72 per cent. of tungsten and 3·15 per cent. of tin.

Economic considerations.

Judging from the above it seems probable that India will become a producer of wolfram in the future. At present there is not likely to be any internal demand for this mineral, and therefore the mineral will be exported in the raw condition, if necessary after preliminary concentration. Tungsten-ores are valued according to the percentage of tungstic acid (WO_3), the market price at the beginning of 1909 being 26 to 27 shillings, and, at the beginning of 1910, 42 to 44 shillings per unit. The chief demand for tungsten is for the manufacture of tungsten-steels, which possess self-hardening properties, and are used chiefly for high-speed machine-tools, heavy guns, and armour-plate. In the metallic form, tungsten is used as a filament in the new tungsten incandescent lamps; whilst tungstate of soda has long been used as a mordant, and for rendering vegetable tissues, such as linen and cotton, non-inflammable.

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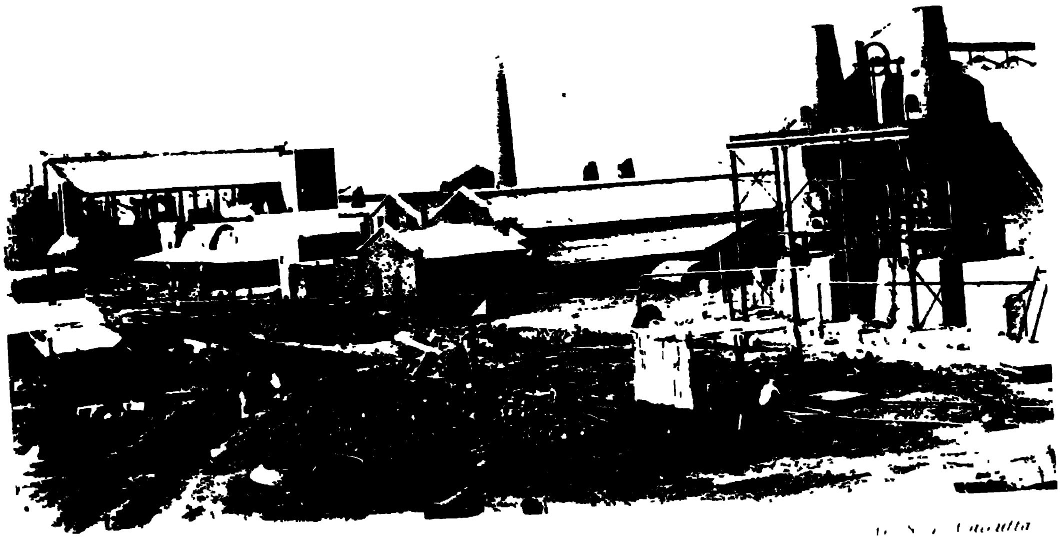
T. H. Holland, Photo. *G. S. I. Calcutta.*

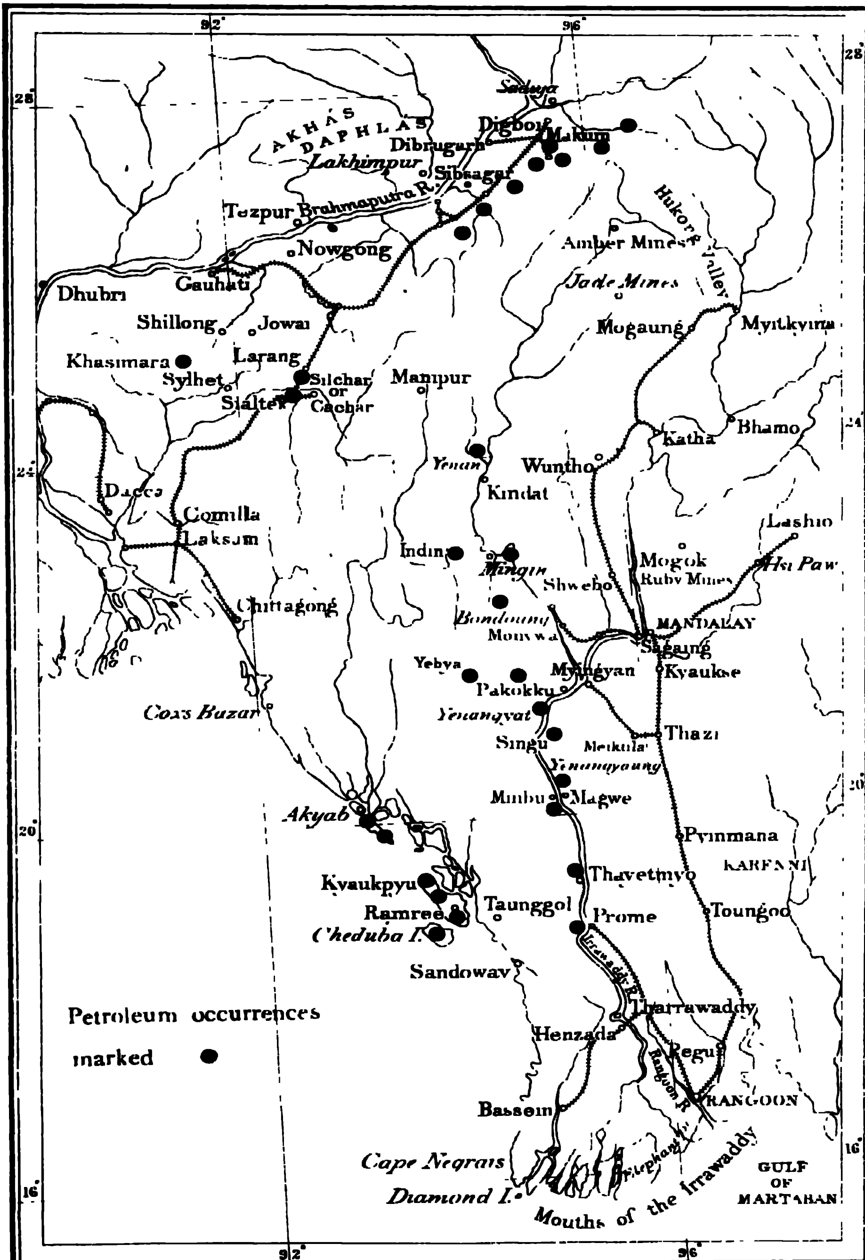
BLAST-FURNACES AT THE BARAKAR IRON-WORKS.



T. H. Holland Photo

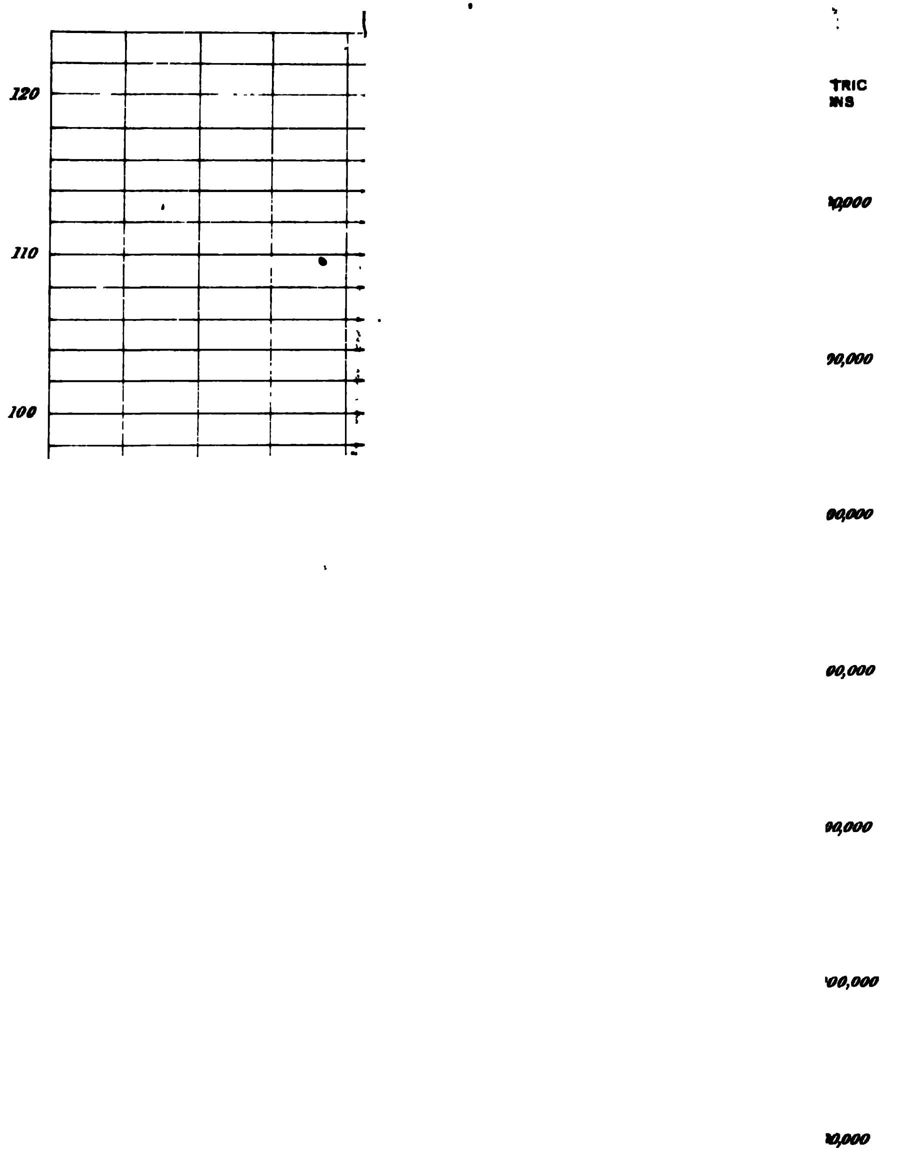
G. S. I. Calcutta

FOUNDRY DEPARTMENT, BARAKAR IRON-WORKS



OCCURRENCES OF PETROLEUM IN ASSAM AND BURMA

Scale, 1" = 128 Miles



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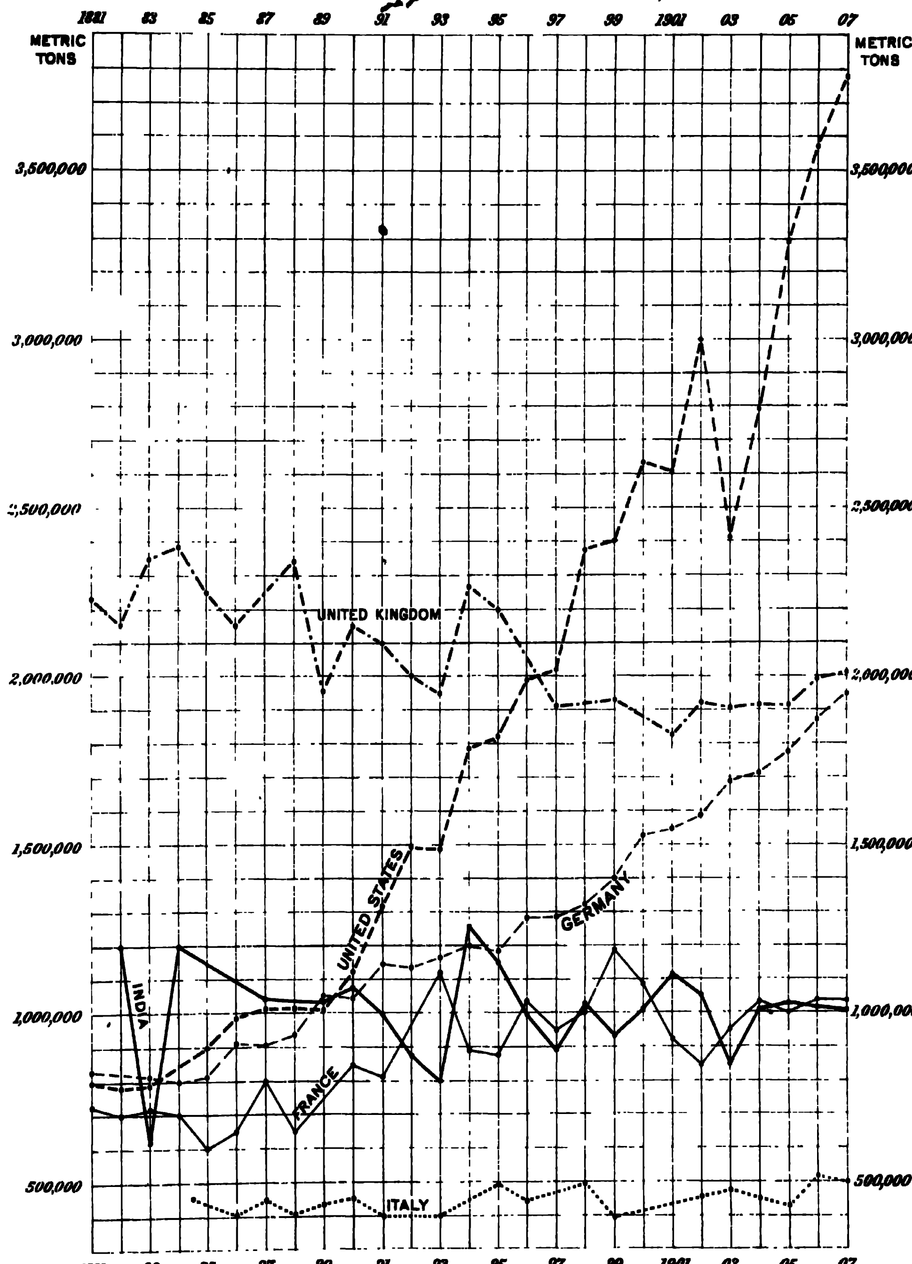

OUTPUTS OF PRINCIPAL SALT—PRODUCING COUNTRIES.

factors which have led to its production; and it is at this stage that we find that one line of speculation has generally been followed.

A few remarks are here requisite on the principal factors which can be supposed to have operated. The primary factor in inducing a provincial development of marine life, *i.e.*, the life of a restricted area, be it great or small, is generally regarded as consisting of masses of land interposed and distributed so as to exclude more or less completely the life of neighbouring areas. Whether such land-masses are supposed to have risen above the water or to have existed merely as submarine barriers, their importance in determining the limits of marine zoological provinces is unquestionable; and by means of the lithological characters and stratigraphical relations of the sedimentary beds their position and extent is frequently ascertainable. But such means of determining the nature of the barriers which existed between zoo-geographical provinces are not always thus available, and it is too often the case that purely hypothetical land-masses are introduced in order to shut in and separate the different faunas. But it must be remembered that negative features of the earth's crust, such as deep depressions, troughs and valleys sunk below the general level of the ocean-bottom, act the part of barriers for certain forms of marine life quite as effectively as positive features represented by land-masses or mountain-chains rising out of the water or forming submarine plateaus or ridges on the sea-floor. In so far as such features affect animal life in the sea, we know that the movements and migrations of such faunas as those which are mostly preserved in the fossiliferous rocks are chiefly effected laterally along shore-lines, and that the extension of a fauna is closely connected with the continuity or discontinuity of the littoral province. A break in the coast, an interval of steeply shelving shore, or an interruption in the continental shelf proves a great or insuperable obstacle to the spread and intercommunication of shallow water faunas, though in time some members may be able to cross the barrier.

It may be pointed out that the length of time necessary for any such barrier to produce a marked effect on a previously homogeneous fauna must be great; and we cannot lightly pass over the difficulties connected with the tectonic origin, rate of formation and subsequent history of any such submarine features. Sufficient importance has not always been attached to these aspects of the question.

It is sometimes forgotten that there are other factors less material and less tangible but more readily capable of disturbance and re-arrangement which influence the distribution of marine organisms to a profound extent. Changes in their intensity, their position or their line of action do not necessarily require geological processes of the same class as those concerned with the production of negative or positive crustal barriers; and indeed it is conceivable that such changes may take place without leaving any mark on the character of the sedimentation, and that in the absence of fossils they may pass by without leaving any record. But on marine life they must produce a deep impression.

Such factors are temperature, light, salinity, ocean-currents, food-supply, depth of water, etc. (5, 6). It cannot be doubted that these exercised an important influence in the past, and their operation must not be neglected, particularly in so far as they must have helped to define the limits of zoo-geographical provinces. It may not always be easy or even possible to determine which of these factors have been at work, or to disentangle their individual effects on the fauna from the combined result. But where land-barriers are hypothetical or improbable, we may suspect the action of one or more of these factors. This is particularly the case when we recognise that the benthonic and pelagic elements of the fauna are subject to different laws, and do not respond in the same way to the same forces. The pelagic element, for example, may find little or no obstacle offered to its free and wide diffusion by a partially submerged ridge. but may be highly susceptible to temperature, currents, or climatic zones, whereas benthonic faunas of absolutely different types may live on the opposite sides of such a ridge. A fauna, therefore, composed mainly of planktonic or nektonic members will tend to have, *ceteris paribus*, a much wider horizontal extension than one composed of benthonic organisms. Such considerations must not be put aside in dealing with fossil faunas, and Walther (7, 8) and others have emphasised their importance and pointed out that the marine conditions of life are reflected in the constitution and character of the local faunas to a much greater extent than is frequently admitted. We cannot doubt that less material factors than solid land-masses or submarine rock-barriers have often determined the nature of the organic assemblages which we find fossil in Palæozoic and later sediments. But the direct influence of climate on marine life has been undoubtedly

over-estimated, and has had less to do with the distribution of marine invertebrates than was formerly supposed.

It may indeed be questioned whether the definite effects of intangible forces, such as those mentioned, are likely to be detected, and much less determined accurately, in dealing with extinct organisms and fossil faunas; yet there is no justification for denying or overlooking their possible influence, or for inserting a hypothetical isthmus or peninsula or other land-mass to account for the differences between adjacent faunas when isolation by dissimilarity of physical conditions in the same basin offers a possible solution. Strong collateral evidence of a stratigraphical and lithological nature should be required before accepting geographical restorations based on faunistic peculiarities.

Amongst the more important factors in determining the character and diffusion of a marine fauna temperature perhaps ranks first; the intimate connection between its distribution and the course, depth, etc., of ocean-currents is well established, and it must be admitted that they are likely to have produced effects in the past analogous to those in the present (**9**). Though the principles and methods of palæogeography are dealt with at length by Arldt (**10**); yet the bearing of recent hydrographic work on marine biology seems to be insufficiently observed, and too much importance is attached to the position of land-masses in determining the distribution of marine organisms.

From the above considerations it appears wise to exercise great caution in attempting to draw the outlines and boundaries of continents and oceanic areas by means of palæontological data alone when other evidence of the geography of the period is wanting.

Cambrian.

The old idea of the world-wide diffusion of an uniform fauna in Cambrian times finds few supporters at the present day, though we still come across traces of this belief in unexpected places. When it was held that the Cambrian fauna was composed of the earliest forms of life which appeared on the earth and that no organic life existed before it, the theory of cosmopolitanism had much in its favour. But as soon as it was recognised that highly differentiated zoological groups and specialised types were contained in it, it was

evident on any theory of evolution that the beginnings of life must be sought for in far more ancient deposits, and that a certain amount of geographical differentiation of faunas and local adaptations of their members must have taken place before the Cambrian beds were deposited. A cosmopolitan uniformity could not have been preserved even in the most freely communicating seas, and the evidence for geographical evolution in Pre-Cambrian times is sufficient to show that the supposed original world-wide fauna (if such is proved to have ever existed) must have been divided up into separate communities which would tend to evolve more or less distinct characteristics of their own. Definite evidence pointing to the accuracy of such *à priori* considerations has been steadily accumulating for years past, and it may now be regarded as a well-established fact that life-provinces existed in Cambrian seas. Progressive development, both geographical and organic, produced further differentiation and greater diversity as time went on, though occasionally provincial faunas were swamped. The difficulties which beset any attempt to mark out the boundaries of the provinces were long regarded as insuperable, owing to the scantiness of the evidence and want of information about the geology of large tracts of the earth's surface. Even now, the sketch-maps which have been published by various authors are generally considered as highly speculative. Frech (11), who has drawn up one of the most satisfactory outlines of life-provinces in Cambrian times, has not failed to point out the imperfection of our knowledge. But since the publication of his maps and conclusions, a considerable amount of fresh knowledge has been gathered from new quarters, and the evidence from Europe has been revised and enlarged. Though still sadly lacking in completeness, the new information throws much light on some parts of the problem, and it is therefore advantageous to review the generally accepted ideas of Cambrian and later Palæozoic life-provinces, particularly so far as Asia is concerned, since some of the most important discoveries have been made in this continent.

Frech recognised in Lower Cambrian times the existence of (*A*) a North Atlantic Sea which embraced the whole of Northern Europe and extended westwards to America, spreading down the whole Atlantic coast from Labrador to Alabama; to the east of Europe it was perhaps connected by the Arctic Ocean with the Siberian and Chinese Seas, and southwards it sent out an arm to Sardinia

and possibly to Spain; (*B*) a second marine province which included the basin of the Rocky Mountains and Pacific coastal area, and was separated from the North Atlantic Sea by a land-barrier running in a general southerly direction from a northern land-mass; a connection of the two marine provinces, however, probably existed across the Southern United States and Central America; (*C*) a third province called the Punjab province, which covered the Salt Range of India and adjacent region, and in his map is made to reach to Australia; (*D*) a Siberian and a Chinese Sea, which are shown as forming part of the great Pacific province, but whether they were separated partly from it or from each other is uncertain. Finally the existence of a sea (*E*) over South Australia was indicated on his map, but its connections were left doubtful.

In Middle Cambrian times a transgression of the North Atlantic Sea is known to have taken place towards the south of Europe, Bohemia and Central France being now covered by the sea. But on the other hand the sea retreated from its western shores, withdrawing from the Atlantic coast provinces of America. The Southern and Central European gulf, which was formed as above stated, had only an indirect and partial connection with the main northern sea, so that it developed the features of a sub-province. The Pacific and Rocky Mountain province at this time definitely extended its limits, spreading out to the opposite shores of the present Pacific Ocean and beyond them, and thus absorbing the Siberian and Chinese Seas. Accordingly, elements of the Western American Middle Cambrian fauna are found in China and Siberia. At the same time certain distinctive features of this province, as contrasted with the North Atlantic province, are strongly noticeable, such as the absence of the genus *Paradoxides* and the appearance of the oldest Asaphids, *Ogygiopsis*, *Dolichometopus* and *Asaphiscus;* but Frech is incorrect in stating that *Microdiscus* is absent from this region, for it is now well known on both sides of the Pacific at this period. Frech makes no mention of a Punjab province or South Australian Sea in Middle Cambrian times, no evidence of the occurrence in those parts of deposits of this age having been then obtained.

In Upper Cambrian times Frech shows that the North Atlantic was contracted in area, the sea retreating from Central Europe. On the other hand marine conditions spread over Central North America eastwards from the Rocky Mountains, the Algonkian continent

being submerged, but no connection with the North Atlantic Sea was thus produced, for the Arctic land-mass projected southwards down Eastern America interposing a barrier between the American and Atlantic faunas. The enlarged Pacific now covered also almost the whole southern half of North America, and westwards it embraced Northern China, while to the south it may have reached Argentina, South Australia and Tasmania. The genus *Dicellocephalus* was characteristic of this huge marine province, while the European province was marked by the genus *Olenus* which was apparently entirely absent from the Pacific; a number of peculiar genera of trilobites were also restricted to the European province.

Such in brief were Frech's conclusions, and though certain modifications are necessary, the principal outlines hold good still. We may now examine the views of other geologists and criticise the various conclusions in the light of recent work.

There is general agreement that the similarity of the faunas on both sides of the Atlantic points to the existence of a North Atlantic province in Lower and Middle Cambrian times, and that the Atlantic coast-line of North America and the northern part of Europe were covered by a common sea allowing of free intercommunication between its different parts. The separation of this province from a Pacific province by a mass of land running down from north to south and dividing the present North American continent into an eastern and western half is also generally conceded. Kayser (**12**), Haug (**13**) and Walther (**14**) are in agreement on these points with Frech, but they do not enter into a discussion of the changes in Middle and Upper Cambrian times as to the extent of these marine basins, nor does Kayser hold with Frech or Haug that the Siberian faunas belong to the North Atlantic province, but includes them in the Pacific one. The recognition of two subprovinces in the European area in Middle Cambrian times is noticed by Haug, who points out as distinctive features the limitation of the genus *Sao* to the Bohemian and of *Microdiscus* to the northern region. Frech's "Punjab province" of the Lower Cambrian times is mentioned by Kayser and Walther as embracing India and Australia, but Lorenz (**15**) is more cautious and remarks that the Salt Range fauna gives no sure indication of its affinities. It may here be stated that Walcott (**16**) has expressed the view that there is no evidence that the Salt Range beds should be palæontologically

referred to the Lower Cambrian and he would place them in the Middle Cambrian. Holland (**17**), however, remarks that "we may safely assume that these beds are equivalent to the Lower Cambrian of the European scale." Haug insists on a direct communication having existed between Scandinavia and Siberia by way of the Arctic Sea, as indeed Frech suggested; for the former believes with Toll (**18**) that there are important affinities between the faunas of these two regions. The Northern Chinese area (Shantung) is also believed by Haug to have been connected on the one hand with Siberia and Scandinavia, and on the other hand with Western North America, that is, the Pacific province, for in all of them occurs the genus *Dorypyge* (*Olenoides*). Haug would, therefore, link up the North Atlantic with the Pacific by way of Siberia and China, but whether only in Lower or also Middle and Upper Cambrian times such a connection is postulated is not made clear. Lorenz (**15**) gives further reasons why a connection between the Scandinavian and Shantung seas existed in Middle Cambrian times; for he lays stress on the common occurrence of the genera *Anomocare* and *Solenopleura* as well as *Dorypyge*, and also instances the gasteropod genus *Raphistoma*. It is curious to attach much importance to the latter as it is nearly cosmopolitan and has a considerable vertical range. The individuality of the Pacific province is further reduced if we agree with his contention that the typically Western American genus *Bathyuriscus* is identical with the Swedish *Dolichometopus* or at any rate only subgenerically distinct. Lorenz goes so far as to doubt the effectiveness of the barrier between the eastern and western seas of North America in Middle Cambrian times. By attaching little importance to local differences, he is led to suggest that a general equatorial connection existed between the seas of the Middle Cambrian period. Arldt has expressed practically the same view (**10**, p. 442). We are unable to assent to such a sweeping generalisation, for it appears unsupported by the evidence now available if fairly weighed and minutely examined. Even when dealing with presumably pelagic elements in the fauna there seem insufficient grounds for such a conclusion. It is of course impossible to deny that some genera which were thought to be restricted to a particular area are now proved to have had a wider distribution or to have been independent of provincial limits, and we cannot be surprised that the extension of research should reveal such facts; conversely, however, it is true that detailed investigation

reveals new peculiar forms (*e.g.*, as seen by recent work on the Cambrian of China) and that many supposed identical species are merely representative (**4**) or 'vicarious,' as Brögger has termed them. The increase in the number of known cosmopolitan or widely distributed forms of generic or subgeneric rank has been apparently balanced by an increase in the number of known locally peculiar or restricted forms. It is found, too, that as a rule the more widely distributed a certain type of organisms is the more persistent or long lived it is; and such organisms possessing great horizontal diffusion or vertical range are not those chosen by zoogeographers for the definition of life-provinces, for they are regarded as unsuitable or even misleading. Detailed stratigraphical and palæontological work, such as Walcott's (**19**) on the Cambrian of North America, has more firmly established the existence of distinct marine basins and provinces instead of merging them into one common ocean with free intercommunication between all its parts; and it may be with confidence asserted that as additional evidence is gathered the existence of more or less distinct and separate faunas is being confirmed in all parts of the world and for the successive geological periods.

It is particularly with the Pacific province, its limits and characteristics, its connections and relations, that we are now concerned, for the recent discoveries of richly fossiliferous Cambrian beds in China by the Bailey Willis expedition (**20, 21**) and in the Himalayas by the Geological Survey of India (**22**) throw much new light on the whole question. The existence of the Punjab or Indo-Australian province instituted by some of the above-mentioned writers is also intimately affected by it. In the first place, the Spiti collections from the Himalayas, which the author has been recently investigating and of which the full description is now published (**72**),[1] possess the remarkable feature of exhibiting a stronger affinity with the Middle Cambrian fauna of the Pacific slope of Western America than with that of any other area. Dr. Walcott, who has examined the material, confirms this conclusion. The whole facies of the fauna is similar, and this is especially brought out amongst the trilobites which form the largest element; for not only are certain

[1] The Cambrian Fossils of Spiti, Palæont. Ind., Ser. XV, Vol. V, Mem. No. 4, pp. 1—70, pls. I—VI. A brief summary of my conclusions has been published in the Annual Report of the Geological Survey of India for 1907 (*Rec. Geol. Surv. India*, Vol. XXXVII, 1908, pt. 3, pp. 26-28).

genera (*Oryctocephalus* and *Zacanthoides*) present which had been previously unknown outside the Western States and British Columbia, but a large number of the species of the other genera are represented by closely allied forms or "vicarious" species, as for instance in the case of *Agnostus*, *Microdiscus*, and *Ptychoparia*. The same similarity is noticeable amongst the few brachiopods and the members of other groups. We must not, however, fail to observe that there are many genera wanting in the Spiti fauna which are highly characteristic of the beds on the other side of the Pacific Ocean, such as *Ogygiopsis*, *Asaphiscus* and *Dolichometopus*, and that the presence of *Bathyuriscus* and *Dicellocephalus* in Spiti rests on a somewhat insecure foundation. The absence of the typical European genus *Paradoxides* is, however, as marked in Spiti as in Western America and all parts of the Pacific province.

The composition of the fauna of the Spiti Cambrian beds is as follows :—

> *Agnostus* 1 sp., *Microdiscus* 2 sp., *Redlichia* 1 sp., *Zacanthoides* 1 sp., *Oryctocephalus* 1 sp., *Ptychoparia* (and its subgenera) 14 sp., *Agraulos* 3 sp., *Anomocare* 1 sp., *Schantungia* 1 sp., and three doubtful forms referred to *Olenus*, *Bathyuriscus*, and *Dicellocephalus*.

With the exception of *Redlichia* which is not found associated with any of the other trilobites and occurs in a different locality and probably on a lower stratigraphical horizon, all the above trilobites are found in one section in the Parahio valley, exposing a conformable series of beds. There are also two species of *Hyolithes*; and amongst the brachiopods *Nisusia*, *Lingulella*, *Lingulepis*, *Acrotreta*, *Acrothele* and perhaps *Obolella* are represented. A species of *Eocystites* and one of *Coscinocyathus* complete the list.

Of the three doubtful genera of trilobites, the occurrence of *Olenus* (if verified) would be surprising, for in America the genus *Dicellocephalus* replaces the European *Olenus* in the Upper Cambrian, and the form referred by Waagen to *Olenus* (*O. indicus*) in the Salt Range can hardly be considered well established, since the fragment on which it was based was scarcely sufficient for a generic determination (**16**, p. 255). The Spiti species referred to *Bathyuriscus* with some hesitation has been provisionally placed in this genus at Dr. Walcott's suggestion, while it must be admitted

that the form doubtfully placed in *Dicellocephalus* may only be some abnormal member of the protean genus *Ptychoparia*, a genus which must ultimately be revised and subdivided. All these three doubtful forms occur together and only in the highest zone in the Spiti section, and as they are not associated with the others and do not affect our general conclusions we may eliminate them in our survey of the fauna.

Of the other trilobitic genera, *Agnostus* is cosmopolitan; *Microdiscus* is spread throughout North Europe, America, Siberia (**18**) and China (**23**, pp. 7, 24). *Redlichia* is an important genus, for it appears to be confined to Eastern Asia; the same species is found in Spiti as in the Salt Range, and it may be here again remarked that Walcott (**16**) is inclined to refer the Salt Range beds containing it to the Middle rather than to the Lower Cambrian. *Redlichia* is represented by several species in the Lower and Middle Cambrian of China (**23**) and is said to range up to the summit of the Middle Cambrian in that country, while some of the species are undoubtedly very closely allied to the Indian *R. Noetlingi*. No example of this genus has yet been recorded from Siberia or any other part of the world. Since the morphological relations of *Redlichia* are undoubtedly with *Olenellus* rather than with any trilobites of the Middle Cambrian fauna, the bed in which it occurs in Spiti as the only trilobite in the fauna may possibly be referred to the Lower Cambrian. The predominance of this trilobite in the Man To formation in China has led Walcott (**23**, p. 4) to place these beds in the Lower Cambrian, so that our attitude to this question of its age is not without indirect support. Unfortunately, though the species of *Redlichia* in Spiti is the same as that in the Salt Range, no other members of the fauna found associated in the latter region have yet been discovered. It may here be mentioned that Frech adopted Waagen and Redlich's conclusions without comment in referring the Salt Range beds to the Lower Cambrian, and he based his "Punjab province" on their peculiar fauna. But it cannot be forgotten that there is no unquestionable evidence of their Lower Cambrian age.

Passing on now to other genera among the Spiti trilobites, we may first note that *Zacanthoides* and *Oryctocephalus* are typically Middle Cambrian forms of Western America. Frech (**11**, p. 51) considered *Olenoides* as identical with *Zacanthoides*, and Woodward (**24**) did not separate them generically, but Lorenz (**15**, p. 87)

seems to be right in maintaining their independence. It does not appear that *Zacanthoides* sens. str. has been, therefore, truly found on any previous occasion outside the American continent. *Oryctocephalus* has also never been previously recorded in any part of the world but British Columbia and the Western States; its occurrence, consequently, in Spiti is of great interest, particularly as one of the species seems identical with *O. Reynoldsi*, Reed, from Mount Stephen, B.C. The genus *Ptychoparia* (which is made to include a somewhat miscellaneous collection of species) is represented in Spiti by a larger number of species than any other genus; many of them are very closely allied to the Western American species, and there are some Chinese species recently described by Walcott which have marked affinities. There is only a remote suggestion of relationship with Scandinavian forms in the case of the great majority of the Spiti members of this genus. The species of *Agraulos* and *Anomocare*, so far as they are known, show likewise American affinities, and if *Bathyuriscus* and *Dicellocephalus* are rightly to be included in the list, the resemblance is further intensified. It may be here remarked that Lorenz (**15**, p. 87) has recorded a species of *Bathyuriscus* from Shantung, and that his *Amphoton Steinmanni* (**15**, p. 89) is to be regarded as a near relative to *Bath. Howelli*, Walcott, from Nevada. But Walcott (**23**, **25**) does not record any species of *Bathyuriscus* in his lists of the Bailey Willis collections from China, though several forms are referred to the genus *Dolichometopus* which Lorenz considers almost or quite identical. Species of *Dicellocephalus*, however, are recorded (with a query) by Walcott from Upper Cambrian beds in Shantung.

With regard to the brachiopods, the best preserved one, belonging to the genus *Acrotreta*, is most closely allied to a Middle Cambrian species from Utah.

Of the other fossils the occurrence of the genus *Eocystites* in Spiti and both Eastern and Western America is noteworthy; and the genus *Coscinocyathus* is known from Sardinia, Siberia and China.

It would be premature to discuss in detail the affinities of the individual members of the Spiti fauna with those of the Chinese Cambrian till Dr. Walcott's complete memoir on the palæontology of the Bailey Willis collections is published, but through his kindness the present writer has had the privilege of seeing advance copies of the plates which will be used to illustrate it. A most striking similarity is seen in the species of *Redlichia* and

indeed in the occurrence of the genus itself, as above mentioned. On the other hand, it cannot be definitely stated that any of the Chinese and Spiti species of *Ptychoparia* are identical, nor do those of the other genera common to the two regions show any very marked resemblances. In fact, the differences between the Chinese and Spiti faunas are considerable; for, after excluding those genera occurring only in the beds referred by Walcott to the Lower or Upper Cambrian, we find the following trilobites unknown in Spiti :—*Dorypyge, Dorypygella, Olenoides, Damesella, Dolichometopus, Drepanura, Chuangia, Arionellus, Menocephalus, Pterocephalus, Ptychaspis, Blackwelderia.* If we refer any of the Spiti beds to the Upper Cambrian, there are a few more to be added (*Pagodia* and *Illœnurus*), while the peculiar genera described by Monke (**26**) and others (**27**) from Shantung (*Stephanocare, Teinistion, Liostracina*) are all absent. Indeed the whole composition of the Chinese fauna appears to be different, though to what extent this is due to special local conditions of life or to slight difference in age rather than to its separation as a distinct zoological province it is impossible at present to decide. At any rate we have to note a large development of peculiar generic types in China unknown elsewhere, and apart from *Redlichia* and possibly *Shantungia*, none of the specially Asiatic genera are common to the two areas. Such widely-spread genera as *Ptychoparia, Agraulos, Anomocare, Agnostus* and *Microdiscus* occur in both faunas, but in so far as they are known the Chinese examples of these genera have chiefly Scandinavian affinities, while the Spiti forms are more allied to American species.

From the above examination of the elements and composition of the Spiti Cambrian fauna it is seen that it is more like that of Western America than that of China.

Bailey Willis (**21**, plate 4) shows the Chinese Sea of the Sinian (=Cambro-Ordovician) period sweeping round the south side of a large central Tibetan island as a narrow strait shut in to the south by the margin of Gondwana-land. This strait he calls 'Southern Tethys,' and it joins up eastwards with the main Tethys. To the north of this Tibetan island the northern Tethys extends. But his conclusions which are based on geological rather than palæontological data are disputed by Hayden and Burrard (**28**, p. 251).

With regard to the connection of the Siberian Sea with that of China on the one hand and with the Pacific on the other, we must note that Toll has described the Nevadan trilobite *Bathyuriscus*

Howelli, Walcott, from the Middle Cambrian of Siberia and has stated that the Siberian species of *Microdiscus* are allied to some found in Western America. The genus *Dorypyge*, which has been detected by Kayser (**29**) and Walcott in China, is also recorded by him from the Siberian Lower Cambrian, and if it is identical with *Olenoides* which is a typical Western American genus, is an additional proof of a connection with the Pacific province. But *Dorypyge* has recently been found by Grönwall (**30**) in the Paradoxides beds of Bornholm, so that its geographical distribution must have been very wide. The presence of *Archæocyathinae* in the Siberian Lower Cambrian is considered an European feature, on which Toll lays stress, but as this group of organisms also occurs in Australia its distribution appears to have been cosmopolitan.

From the above evidence we can trace a connection of the Chinese-Siberian Sea with the Pacific Ocean on the one hand and on the other with the Atlantic province, as Toll pointed out and Frech accepted. Northern Asia thus seems to have been covered by a sea of communication between the Eastern and Western Hemispheres in Middle Cambrian times; and links between the faunas of Norway, Bornholm, Siberia, China and Western North America were established by this means. Toll was not sure whether the Sino-Siberian Sea was connected with the European North Atlantic province southwards by way of the Salt Range or northwards by way of Northern Russia. But the absence of any close similarity between Siberian, Chinese, Spiti and Salt Range faunas seems to preclude the former, while the latter theory is supported, as Grönwall points out, by the occurrence of *Dorypyge* in Bornholm and of Paradoxides beds of Scandinavian type in Poland.

Our ignorance of the existence of any Cambrian beds in Persia, Asia Minor or North East Africa prevents any definition of the boundaries of the Pacific province in this region to the west of India, but we may reasonably hold that a barrier of some nature effectually checked the free intermigration of the typical European and Asiatic faunas in this direction during Cambrian times; no Mediterranean or ancestral Tethys is proved by palæontological evidence to have then been established, and the dissimilarity between the nearest European fauna and that of Spiti and the Salt Range is therefore strongly marked. Eastwards of Spiti we may conjecture that a more direct and uninterrupted communication existed with the Western American sub-province than with

that of the Chinese Sea to the north. Whether the Siberian Sea had a freer connection with the Pacific than with the Atlantic is difficult to say, as there seems to have been in it an intermixture of faunas; but the comparative isolation of the Chinese basin from not only the Siberian Sea but also the Pacific and Himalayan regions must have been fairly complete, in order to account for the extraordinary development of peculiar generic types and their restriction to it.

In Southern Yunnan a species of *Mesonacis* has been discovered in beds which are referred to the Lower Cambrian. This genus, while absent from Northern China, is a typical Lower Cambrian type of the Pacific province in America; so that it seems to support the theory here put forward of a somewhat direct and close connection between the Himalayan region and Western America.

As regards Australia, we may note that the genus *Olenellus* has been found in North, South and West Australia in Lower Cambrian beds, while *Microdiscus*, *Ptychoparia* and *Dolichometopus* occur also in South Australia. None of these are exclusively or typically Pacific forms, but are almost world-wide in their distribution, so that the theory of an Indian connection is not supported by their occurrence. Indeed the absence of *Olenellus* from the Punjab and Spiti is directly opposed to it. The only peculiarly Indian form of Cambrian age is the genus *Lakhmina* which has been recorded from Victoria. But the Cambrian fauna of Australia, so far as it has been described, is so fragmentary and scanty, and the material so poor, that no zoo-geographical conclusions of much value can be drawn from it; and consequently it is best to desist from speculation about the relations of the seas in which it lived. No Middle Cambrian has so far been recognised at all in Australia.

Returning to Asia, we still notice in Upper Cambrian times the comparative isolation of the northern Chinese region, but members of the *Dicellocephalus* fauna of America seem to have spread into it. No undoubted example of the genus *Olenus* or of any of the associated genera of trilobites of the European *Olenus* stage has yet been detected in Asia, so that probably the pre-existing connection with the North Atlantic province was much reduced or even severed. The history of the Indian region in Upper Cambrian times is unknown or at any rate uncertain, but a conglomerate lies unconformably on the fossiliferous Middle Cambrian of the Himalaya and forms the base of the Ordovician

beds (**22**). That the *Dicellocephalus* fauna extended far southwards is, however, suggested by the occurrence of this genus in Tasmania (**31**). In China (**21**, p. 50) the interruption in the process of sedimentation took place later.

Finally, we may quote some appropriate remarks on the Cambrian history of the Himalaya which are made in Messrs. Burrard and Hayden's recent work on the geography and geology of that region (**28**): "The presence of rocks of the Haimanta System[1] in Kumaun, Garhwal, Spiti and Kashmir proves that these areas at least were submerged, whilst during the latter part of the Haimanta period the sea extended also to the Salt Range of the Punjab where the Cambrian rocks contain a species of trilobite identical with one from the uppermost Haimantas of Spiti. Westwards the same sea probably extended at least as far as the Hindu Kush and Afghanistan, but it was not connected with the Cambrian Sea of Europe, for the fauna of the fossiliferous rocks of this age in the Himalaya has nothing in common with that of the European Cambrian. On the other hand, there are decided affinities between the Cambrian fossils of the Himalaya on the one hand and those of China and North America on the other, and this has been regarded as evidence of a sea-connection between the Himalaya and America during late Haimanta (Middle Cambrian) times."

Ordovician.

A brief résumé of the commonly accepted conclusions put forward by Frech (**11**, pp. 88—98) may be advantageously given before discussing the effects of recent discoveries on these views. Frech recognised four distinct marine provinces in lower and middle Ordovician times:—

(A) The Bohemian-Mediterranean, embracing Bohemia, Thuringia, the Eastern Alps, Southern France, Spain and Portugal.

(B) The Baltic, embracing Scandinavia and the Russian and German Baltic Provinces, with an extension inland into Russia to Minsk and including Poland and probably reaching northwards to Greenland. Siberia, Eastern China and the Himalaya were also probably included in this province.

1 This system as here understood partly corresponds with the Cambrian. The name was employed in this sense by Sir T. Holland in 1907 in his original scheme of classification of Indian formations (**17**).

(C) The North Atlantic, embracing the British Isles (with the exception of northern Scotland), Belgium and northern France. In the west or middle of France a connection existed with the Bohemian Province.

(D) The Pacific-North American, including the eastern part and whole centre of the continent, and perhaps the northern Pacific and the North American Polar regions.

It was felt uncertain to what province the immense Ordovician district in the middle of Siberia should be assigned.

The independence shown by the graptolites of these provincial boundaries was noted by Frech, but was considered explicable by their pelagic mode of life.

Kayser (**12**, p. 102) did not enter into such detailed subdivisions, but recognised one Periarctic development as the normal type throughout the world, and regarded it as embracing not only northern Europe and North America but also the Arctic regions, Asia and South America. The Bohemian or Mediterranean facies was regarded as purely local. Practically, Kayser did not attach much value to Frech's distinctions. Haug (**13**, pp. 660—662) recognised the existence of only three zoological marine provinces in Ordovician times: (1) the North European, (2) the Bohemian, and (3) the American.

Walther (**14**, p. 236) has adopted Frech's classification, but has added a fifth province embracing an East Asiatic ocean.

The basis of all these schemes is the distribution of the trilobites, and Frech gave lists of genera illustrating the differences between the respective provincial faunas. But these lists require some modification as the result of recent work. Thus, amongst the Baltic genera which Frech believed to be absent from the British Isles were *Nileus*, *Telephus*, *Triarthrus*, *Nieszkowskia*, *Dindymene*, *Parabolinella*, and *Symphysurus*, all of which, with the possible exception of the last, have now been found. Brögger (**32**) has, moreover, pointed out that the genera of the Euloma-Niobe fauna which characterises the *Ceratopyge* Limestone at the base of the Ordovician had a much wider distribution than was previously suspected and that the fauna extended from Sweden to Hof and Languedoc in the south and to Shropshire and Wales in the west; the species, moreover, are often vicarious, if not identical. To Brögger's list we have now to add *Orometopus elatifrons* Angelin, (**33**). Törnquist, however, does not admit the uniformity of this fauna over such a wide area, but recognises 3 distinct facies with dissimilar faunas,

and he denies that any of the species are identical. It must, however, be admitted that at the commencement of Ordovician times there was a large marine area overspread by a practically identical type of neritic fauna, which, though possessing small local differences, affords clear evidence that no barriers of importance existed within the bounds of one huge common life-province. The strong distinction between the Baltic and North Atlantic provinces was temporarily effaced, and the recent discovery of the intimate faunistic relations which existed between south and western Ireland and the Scandinavian area at even a somewhat later date is a warning how considerably detailed investigations may necessitate a modification of our opinions even in the case of well-known countries. The discovery in Galway (**34**) of a small but representative assemblage of fossils which in the Baltic regions would be considered to mark the Orthoceras Limestone, some of the species even being identical, is a case in point. The later appearance in England of members of the Baltic fauna has often been asserted, but it may now prove to be the case that they came from the west, *i.e.*, from Ireland, as much as directly from Scandinavia.

The remarkable affinities of the fauna of the lower portion of the Ordovician system in the Scotch and North American and Baltic areas have long been recognised, and with regard to the trilobites recent work on those of the Girvan area (**35**) has confirmed these views, while the occurrence of such genera as *Maclurea*, *Endoceras* and *Porambonites* as well as the close affinities of many of the species of other genera is well established. The genera *Bathyurus* and *Bathyurellus* are usually regarded as exclusively North American, but (apart from their supposed occurrence in China and Argentina) we can now definitely state that they occur in the lower beds of the Ordovician in the west of Ireland (**34**).* Indeed this latter region seems to have been the meeting place of the several provinces where they interchanged and mingled their inhabitants. The Scandinavian genera *Telephus*, *Nileus* and *Apatocephalus* (**36**) likewise are found in Ireland, the two former ranging also into America; but *Telephus* does not appear in Scotland (Girvan) till somewhat later, *i.e.*, in the Whitehouse Beds (middle Bala) (**35**, p. 44). Frech's

* The final results of my examination of the material collected by Professor S. H. Reynolds and Mr. C. T. Gardiner in the Lough Mask district are being published this year in the Quarterly Journal of the Geological Society of London, Vol. LXVI, 1910, pls. XXI, XXII, pages 271—276.

statement (**11**, p. 90). therefore, that *Nileus*, *Telephus* and *Triarthrus* were present in America but absent from the British Isles, has to be corrected. We can, however, only reduce, by three, the number of European genera missing in America which he mentioned; for *Chasmops*, *Cybele* and *Conolichas* have now to be reckoned as members also of the American fauna (**37**). Amongst the cephalopods *Lituites* and *Ancistroceras* still appear to be unrecorded from America, while *Gonioceras*, *Huronia* and *Eurystomites* are unknown in Europe. The differences between the two life-provinces are thus of no small degree, and when we examine the various zoological groups in detail their importance is further emphasised.

With regard to the apparent differences which were held to mark off the Scandinavian from the British fauna and which we have seen are much diminished by recent work in Ireland and Scotland, Haug (**13**, p. 661) rightly thinks that they may have been largely due to differences of facies, and that no land-barrier need be supposed to have existed in order to account for them; a deep submarine trough would have interposed just as impassable an obstacle to neritic faunas as any solid mass of land. The distinct characters of the Welsh and Scandinavian Arenig faunas seem to have been largely due to a considerable difference in surrounding physical conditions, as suggested by the lithological characters of the rocks themselves. It must not be forgotten that deposits laid down at the same time in the same basin and in adjacent areas may contain totally distinct assemblages of organisms,—in fact, heteropic faunas; and this is particularly the case with benthonic life which is most subject to the influence of the local conditions and cannot readily change its habitat. Moreover, when migration takes place, the fauna rarely, if ever, is transplanted in its entirety, some members dropping out and others becoming modified in the process.

As the Ordovician period advanced, it is generally acknowledged that the earlier differences existing between these two provinces progressively diminished, so that in Upper Ordovician times the distinction is nearly obliterated, as, for instance, we see in the remarkable similarity of the faunas of the Keisley, Kildare and *Leptæna* Limestones (**38**). Even in Scotland (**35**) there are strong traces of this widespread fauna.

The provincial differences in northern Europe thus appear to have been of comparatively small importance in Ordovician times; but there were special peculiarities in the Bohemian or south European region

which marked it off, and Frech's detailed comparison of the two provinces needs little comment, and his conclusions have been generally accepted (**10**, p. 417). The differences between Bohemia and Scandinavia were much more pronounced than between the latter country and the British Isles. A few more Bohemian forms have now to be added to those previously known in England and Scotland, among which we may mention the genus *Bohemilla* (**35**, p. 53) and some identical or nearly identical species of *Cyclopyge* which occur in the Girvan district (but on a higher stratigraphical horizon than in Bohemia). The peculiar crustacean, described by Barrande as *Anatifopsis*, has also been identified in the same district (**39**).

With regard to America, Haug's (**13**) general statement that the Atlantic coastal region belongs incontestably to the north European province, while the region comprising New York and the Central States possesses certain palæontological characters which indicate a connection between its sea and the Pacific basin, is in agreement with the detailed work of Messrs. Ulrich and Schuchert on Palæozoic seas and barriers in eastern North America (**40**). The great interior continental sea to which the name Mississippian has been applied "continued with some interruptions and more frequent modifications of its outline, through all Palæozoic time," and was kept shut off from the Atlantic by the Appalachian folds, but invasions by the north Atlantic took place at times here and there. Further details need not here be given.

As above mentioned, there does not appear to have been a strong distinction of provincial faunas in Europe in late-Ordovician times, the Scandinavian, British and even the Bohemian areas having many species in common and many others very closely allied; the barriers between these faunal regions seem to have been broken down, thus allowing of a freer intercommunication of marine organisms, and uniform conditions appear to have been widespread. But certain differences are still noticeable on a close study of the fossils, though these may be largely due to varying local conditions of existence. Frech (**11**, p. 98) has given a list of a large number of identical or representative species, and several more can now be added from comparative work on the Keisley (**38**), Kildare (**55**) and *Leptæna* Limestones. The "Periarctic fauna", as Frech has termed it, reached Siberia on the east, and the barrier between the eastern and central parts of America was at the same time largely destroyed (**40**). But the resemblance

between the North European and American faunas is not so strong as might have been expected.

The Ordovician in Asia, with which we are specially concerned, has until recently been known only by meagre and isolated observations, and the fossils collected have been too few or poor to furnish sufficient data for satisfactory zoo-geegraphical conclusions. Frech was unable to say more than that there was a general resemblance between the fossils obtained and those of the Baltic province. Lorenz has recently (**15**) collected most of the scattered references to the literature on the subject, and we may specially draw attention to the representatives of the Scandinavian Orthoceras Limestone in Central China (with *Endoceras duplex*, *Orthisina* cf. *squamata*, *Asaphus* and *Raphistoma*) described by Frech (**41**), and to Martelli's list from Shansi (**42**) recording *Porambonites*, while Weller's descriptions (**43**) (**20**, p. 45, etc.) of a Baltic type of fauna, from Szechuan, containing *Clitambonites*, *Ampyx*, *Asaphus*, *Megalaspis*, etc., and even some European species, further support Frech's conclusions. A trace of an American element is however afforded by the presence of a species of *Bathyurus*, and Crick (**44**) has recorded the peculiarly American genus *Gonioceras* from Shantung. We shall revert to this later in describing the Himalayan Ordovician fauna.

The extension of the north European fauna still further south in Asia has been recently illustrated by the description of the Ordovician fossils of the Northern Shan States, Burma (**45**), the whole palæontological facies of these beds being of a well marked kind and showing pronounced European affinities without any definite American elements, · though most of the species are peculiar. Valuable additional evidence has recently (**46**) been obtained by the discovery of a further series of fossils from other horizons and localities in that region. All of them bear an unmistakeable European stamp. The full description of this new material is not completed, but the fauna comprises (1) numerous examples of a species of *Phacops* belonging to the typically Baltic subgenus *Pterygometopus* and allied to *Pt. Panderi* Schmidt, of the Echinosphærite Stage C 1; (2) one or more species of *Asaphus*, referable to the subgenus *Ptychopyge*; (3) species of *Ampyx*, *Harpes*, *Orthisina*, *Porambonites*, etc. The fauna from the Naunkangyi Beds, which the beds yielding these fossils are said to overlie, has a slightly different composition and scarcely any species seem common, but both sets of fossils exhibit the same north European affinities. No

typical Upper Ordovician fossils have yet been detected, and the beds seem to be rather low in the Ordovician System. Schuchert (**47**) in a review of the author's work on the Lower Palæozoic of the Northern Shan States, detects American affinities amongst the brachiopods from the Naungkangyi Beds, but expresses the opinion that the beds "seem to agree fairly well with the Baltic formations marked C by Schmidt (Echinosphærite, Kuckers and Itfer zones), and though less clearly, but still with considerable evidence, with the American interior Galena and Trenton formations." The single Bohemian element shown by the presence of a species of the cystidean *Aristocystis* is interesting, and at present difficult to explain, as the other cystideans are of north European types.

The imperfect fossils recently described by M. Mansuy (**48**) from Tonkin from the "Schistes de Nam-Ho à *Calymene*" and the "Schistes à *Orthis budleighensis*" suggest the presence of Ordovician beds in that region; the species of *Calymene* (*C. Douvillei*) appears to be allied to the Burmese *C. birmanica* Reed, and the Himalayan *C. nivalis* Salter, and the affinities of the brachiopods seem to be European, though the specific identification of some may be questioned.

Passing from Burma to the Central Himalayas, the Ordovician of this region has been comparatively unknown, and Salter's work on the fossils from Niti (**49**) was inconclusive, principally owing to the scanty and poor material with which he had to deal. The fossils from Spiti, Garhwal, Kumaun and Bashahr which are now being described by the author prove the existence of a much richer and more varied fauna, and in the case of Spiti they have been collected from a series of successive stratigraphical horizons. The most remarkable fact which has at present emerged is that the palæontological affinities are not with northern Europe or Burma but rather with that of the "Mississippian Sea" of North America. Hayden indeed some years ago (**22**) recognised the presence of American forms, and several of the species appear to be almost or quite identical. The composition of the fauna is also different to that of Burma, brachiopods predominating and belonging to a variety of genera. The alliance of many of the species to Trenton forms is extraordinarily close, as will be shown in the case of members of the genera *Orthis*, *Triplecia*, *Strophomena*, *Rafinesquina*, *Rhynchotrema*, *Parastrophia* and *Hindella*. Amongst the lamellibranchs and gasteropods there are similar affinities, and amongst

the few cephalopods a species comparable to *Gonioceras anceps* has been recognised. The ostracods and trilobites have mostly American relations where their remains are sufficiently perfect to allow of comparison, and several of the corals are extraordinarily closely allied. In all there are quite two-thirds of the fossils which are specifically determinable possessing American representative species; a few may even be identical; while European elements are conspicuous by their absence, and cosmopolitan forms are rare.

The Himalayan species are mostly peculiar, and at least one peculiar genus occurs, so that the individuality of the fauna is marked. These faunistic characters suggest the presence of unsuspected barriers and lines of communication, but it is not clear by what route the immigration of American types can have proceeded nor how it crossed the strong European wave which seems to have flooded Eastern Asia. The occurrence of elements of the Trenton fauna in Argentina (**50**) points to the southern extension or migration of portions of this assemblage of organisms. But in Bolivia Lake (**51**) describes the Ordovician fauna as possessing European affinities. Kayser (**52**) has on the other hand stated that the Lower Ordovician of Argentina has a mixture of Canadian and north European characters. The extension southwards of northern elements is thus proved, and even further south, in Australia they have been recognised. Though we are not able at present to judge precisely of the affinities of the Australian Ordovician neritic faunas (**53, 54**) (for they are not very pronounced), yet the relations of the species seem to be with north European forms, but some American species have been recorded in Tasmania. The pelagic fauna of graptolites has the usual cosmopolitan character. Frech (**11**, map 2) makes a great tongue of his Indo-African Continent stretch to about 180°E. long., completely shutting off the whole southern portion of Australia (then covered by sea) from the Siberian and Chinese Seas, though leaving it open to the Pacific-American Sea on the east. The sea which spread over this part of the southern hemisphere he terms the South Australian Sea. Arldt (**10**, map 14) makes this sea (the "Southern Sea") continuous with that covering South America, but completely shut off from the North Atlantic and Baltic basins by the unbroken land mass of "South Atlantis" and "Gondwana land."

If distance and difficulty of access were the chief elements in determining distribution of faunas we should expect this Southern

Sea to possess predominant Pacific-American elements rather than European. But this is precisely what it apparently does not. The problem must be left to the future to be solved, and however we may speculate as to the origin of the American element in the Himalayas, it must be allowed that the separation of the Burmese and Himalayan faunas must have been fairly complete. The great expansion of the Baltic province must have been southwards through part of China to Burma, but the precise size of this arm and its boundaries are uncertain. Frech has shown (**11**, map 2) a huge Siberian and Chinese Sea forming part of the immense Pacific-American Sea in Lower Ordovician times and connected across Northern and Central Russia with the Baltic basin proper. How much this great marine area was subdivided by islands, peninsulas or submarine ridges rising from the ocean-floor but not forming land, is hypothetical, at least as far as Asia is concerned; and we are unable to form any conception to what extent ocean-currents and other factors may have led to the curious distribution of life which we now find preserved in the rocks of that area. Arldt (**10**, map 14) draws rather more definite outlines to the land-masses and oceans than Frech dared to do, but our knowledge is too scanty at present to attempt any probable restoration of the geography.

Of the existence of Upper Ordovician beds no clear evidence has yet been obtained from Burma or the Himalaya, but in China Kayser (**29**) has described some fossils which suggest their presence.

Bailey Willis (**21**, p. 51, plate 4) believes that the Central Tibetan Island separating the northern and southern branches of the Tethys persisted from pre-Cambrian to Carboniferous times, but at the end of the Sinian period and soon after the Middle Ordovician (Trenton) fauna had appeared the close of general marine conditions in China took place and a period ensued when little or no sediment was deposited. He notices the interesting parallel which this forms with North America where physical changes of the same kind occurred at this time and were marked by the general lowering of the sea-level.

In the Himalayan region (Willis' Southern Tethys) no interval of erosion or break in the continuity of marine deposits took place, according to Hayden (**28**), and the change in the character of the sediment as evidenced by the Muth Quartzite (**22**, p. 27) occurred after the inception of the Silurian period.

Silurian.

The great transgression of the sea which began in late Ordovician times continued and increased in the Silurian period, and Frech has pointed out how that the same faunistic characters are found throughout northern Europe, Siberia, China and North America. One common Silurian Ocean seems to have spread round the northern hemisphere. In Siberia Toll (**56**) and Lindström (**57**) have laid stress on the north European type of the fauna, and even some of the species seem to be identical, while in China Kayser (**29**) and Lindström have described several European species of brachiopods and corals, though many of the latter are peculiar. Haug (**13**, p. 653) has remarked that the affinities of the Gothlandian of the Himalaya are plainly with those of the north of Europe, and in the Central Himalaya the scanty and badly preserved fauna which the present author has examined points the same way; some European species probably occur, including the almost cosmopolitan *Pentamerus oblongus* of the Llandovery beds, but some American types seem also to be represented. It was at the time of the deposition of the Wenlock and corresponding beds that the greatest extension of the Periarctic Sea took place, according to Frech; and in Burma it has been recently shown (**45**) that the Gothlandian fauna of the Northern Shan States has likewise a north European character. With the exception of one species of *Mimulus* occurring in the Namhsim Sandstones, the fossils of the Panghsapye and Namhsim Beds have Periarctic affinities, and no Bohemian types are present. In Tonkin Mansuy (**48**, pp. 3, 4, 21—33) has described beds with a mixed Ordovician and Silurian fauna as "Schistes à *Orthis vespertilio* et *Spirifer crispus*", but the fossils seem too poor to attach much importance to the specific identifications. Certain calcareous slates near Yen-Lac containing corals which are referred to Wenlock species may, however, be Gothlandian in age.

It is indisputable that in Europe the peculiarities of the northern and southern provinces were largely effaced in Silurian times, as Frech and Haug (**13**, p. 662) have pointed out. This is especially noticeable in the case of the brachiopods and gasteropods, but the lamellibranchs and particularly the cephalopods are more local in their distribution. It is worth noticing that even in these early times the genera and species of cephalopods have a restricted

horizontal range, for such is now recognised to be the case in Mesozoic times (**58**), contrary to former theories about this group.

The interior epicontinental sea of North America in Silurian times seems to have communicated with the north of Europe by way of the Arctic regions, though still shut off from the Pacific (**59**).

In South America the relations of the Silurian fauna were with those of North America, and it contains many allied or representative species (**60**).

With regard to Australia, the mixture of Periarctic and Bohemian forms is the distinctive mark of the Silurian fauna of this region (**11**, p. 111; **31**, pp. 316, 318—321), while in New Zealand there is an intermixture of European and North American species with the local elements (**61**). On the continent of Asia the Bohemian element appears in the uppermost Silurian [or Lower Devonian (**47**)] (Zebingyi Beds) of Burma, and the fauna is here completely Mediterranean, the north European forms being apparently completely absent. The whole lithological development as well as palæontological character of these beds is strikingly Bohemian, as the present author has pointed out (**45**, pp. 152—154).

The cause of this remarkable influx into Burma and of the exclusion of the normal north European successors of the pre-existing fauna is problematical, and speculation on the subject at present is vain. But the immigrants seem to have had a short existence and to have obtained little foothold, for they effected little extension into adjoining regions, so far as our knowledge permits us to judge. A precisely analogous case, occurring at about the same period, is found in the "Helderbergian invasion" of the "Cumberland basin" in North America by which was "brought in a European fauna by way of the Hercynian chain believed to have connected North America with central Europe (Bohemia, Hartz, etc.)" (**40**, p. 649).

Finally, the marvellous cosmopolitan distribution of pelagic members of the Silurian fauna which has been so frequently noticed by various writers, has recently been further illustrated by the discovery of a rich graptolitic fauna in shales of Llandovery and Lower Wenlock age in the Northern Shan States of Burma, comprising many European species of *Monograptus*, etc.

Devonian.

There is a general agreement that at the close of the Silurian or commencement of the Devonian period there was a general retreat

of the sea; the great Periarctic Ocean shrank (**11**, pp. 232—240) to much smaller limits both in northern Europe and in America; only in the Mediterranean region did pure marine deposits continue without interruption to be laid down. Unless we refer Mansuy's "Schistes à *Spirifer tonkinensis*" in French Indo-China (**48**, pp. 5, 34—49) and the Zebingyi Beds of Burma to the Lower Devonian, [as Schuchert does (**47**) in spite of their graptolites,* comparing their fauna with that of the Bohemian limestone of Konieprus], there is no evidence of Lower Devonian in southern Asia at present discovered. The age of these Zebingyi Beds, if decided apart from the graptolites, must be regarded as Lower Devonian, for the rest of the palæontological evidence points that way. At any rate the peculiar Hercynian facies of the fauna is indisputable, and the eastern extension of an incipient "Tethys" is apparent. In the case of the Tonkinese beds Mansuy says that their fauna presents close affinities with that of the Oriskany of North America; a species of *Calymene* is recorded which, though a Silurian genus, may perhaps be regarded as only a survival.

The various movements at the close of the Silurian divided up the marine areas into several more or less distinct basins, as Frech has shown in his map (**11**, map III). But it is unnecessary to describe or discuss in this place the detailed distribution of sea and land which he marks out, except so far as it concerns the continent of Asia. The localisation of the Rhenish and Hercynian facies respectively in the western European and Mediterranean basins is believed to have depended simply on differences of bathymetrical and other physical conditions, as Haug has pointed out (**13**, p. 727), and does not necessarily support the theory of distinct European provinces. However this may be, we find Frech representing the Mediterranean basin as a broad strait connecting the west European basin with the great Altai-Uralian basin which extended over a great part of western Siberia and communicated eastwards with the Pacific Ocean across Central Asia. The rich Lower Devonian fauna of the Urals and Altai possesses a predominant Bohemian element intermixed with a few west European forms. The Zebingyi Beds of Burma, if referred to Lower Devonian, would extend this Bohemian fauna further south. No Lower Devonian fauna has been so far recognised in the Himalayas. The connection of the

* Ruedemann (Mem. No. 7, New York State Museum, 1904) has described four species of graptolites from the Devonian of New York.

Eurasiatic sea with that of North America may probably have been by way of the St. Lawrence-Connecticut depression, according to Schuchert (**62**), but there was a more or less complete barrier down the Atlantic. The details of the faunal distribution and movements in North and South America are fully discussed by Frech (**11**) and Schuchert (**40**) (**62**); the American life-province, however, possessed on the whole, especially in the middle and southern portions, distinctive palæontological features separating it from the Eurasiatic (**12**, p. 154) (**63**), in spite of the resemblance of the faunas of the Lower Coblenzian of the Rhine and of the American Oriskanian. The persistence of the Lower Devonian facies in North America till the end of Hamilton time while the Middle Devonian faunas of Eurasia were spreading over that region is now a recognised fact. The interesting connection of the American Sea in Lower Devonian times with South Africa by way of South America and the Falkland Islands has been discussed elsewhere by the author (**64**), and it is unnecessary to repeat it here. There is no trace of this fauna in the Himalaya or Burma.

The Middle Devonian was ushered in by a great marine transgression, but there was still the distinction between the great Eurasiatic province and the North and South American province (**63**). In Asia the Middle Devonian fauna has been collected from a multitude of places; the one which has yielded the richest results is Padaukpin in Burma. Lorenz (**15**, p. 116) and the author (**65**) have given references to most of the recorded occurrences, and the evidence from all of them points the same way. Mansuy (**48**, p. 6) has recently recorded the fauna from Tonkin. The whole type of fauna is European (**29**, pp. 97—101) (**65**, pp. 138—157) and many of the same species occur, so that the closest affinities are traceable throughout the Ural region, China and Southern Eastern Asia. The "Tethys" which comprised this life-province covered an enormous area in Asia, reaching from Northern China to Burma and spreading over most of the interior, as Suess (**66**), Frech and others (**65**) have pointed out, and there must have been free intercommunication between its different parts. It is, however, interesting to find that when special zoological groups are studied with a view to determining their geographical distribution certain subdivisions of the area become possible, though only applying to the organisms in question. Lebedew (**67**) has shown this in connection with the

corals, and distinguished three sub-provinces—the West European, the Central Russian and the Ural-Altai,—each with special characteristics. It seems that other zoological groups lend themselves to this treatment and may yield suggestive results. The faunal provinces of America in Middle Devonian times have been discussed by Schuchert (**68**), and in the western American or "Dakota Sea" which was cut off from the inland or "Mississippian Sea." he points out that the faunal facies is that of the Eurasiatic province. Lebedew has noted the occurrence of American elements in the coral faunas of his Ural-Altai province, and Stuckenberg (**69**) and Kayser have recorded some American brachiopods in Eastern Asia, while the present author has shown the strength of the trans Pacific element amongst the genera and species of the Bryozoa in the Middle Devonian of Burma (**65**, p. 156).

In the case of the Central Himalayas the poorness of the material of Middle Devonian age prevents an altogether satisfactory analysis of its faunistic characters, but European species of brachiopods (e. g., *Orthothetes umbraculum*) prove the extension of the same life-province to this region (**22**) (**28**, p. 251).

Katzer (**70**) has attempted a somewhat detailed restoration of the geography of this period, and has inserted in his map a great Indo-Australian continent extending from the south side of the Himalayas towards the south-east across Central Australia. The "Southern Ocean" which lay to the south of it was connected with the great Pacific Ocean by means of the "Brazilian connecting Sea" across South America, and with the South Mediterranean Sea by an "Indian connecting Sea" on the west side of the present Indian peninsula. But these seas and straits and land-masses are largely hypothetical, and it seems to the writer wiser at the present time to forbear suggesting the nature of the barriers which separated these life-provinces, or the channels of communication by which the faunas intermixed.

With regard to Australia, a few facts only are available. In western Australia we find European Middle Devonian species, but in Queensland a few American ones are intermixed with many Rhenish forms. Even a peculiar Chinese species of brachiopod (*Spirifer Chechiel**) has been recognised in the Middle Devonian of Tasmania.

* Frech (**11**, p. 248) considers this species to be merely a variety of the Rhenish *Sp, speciosus.*

The distinction of the various zoo-geographical elements in the Middle Devonian faunas from various parts of the Eurasiatic province and a comparison of their relative strength may lead to valuable results, but in most cases outside the European area the scantiness of the material and imperfection of the fossils preclude accurate work on these lines.

The peculiar fauna of the Wetwin Beds of Burma (**65**, pp. 157—183) is marked by the occurrence of many species allied to or identical with those occurring in the Hamilton Group of North America, and especially with members of the Naples fauna of Frasnian (Upper Devonian) age (**71**). But the precise age of the Wetwin Beds is still uncertain. At any rate we must note that the facies of the fauna is unlike that of any in Europe and that the relations of the majority of the species are also not with European forms. The Upper Devonian faunas which have been described from Eastern Asia (**65**, pp. 146—154) are completely different from that of Wetwin, the species being distinct and the proportions of the different zoological groups being dissimilar.

It was at the period represented by the lower portion of the Upper Devonian that the greatest extension of the sea took place, according to Frech (**11**, p. 256), and at this time the distinctions between the various marine zoological provinces were mostly obliterated. But before the close of the Upper Devonian a negative movement had begun in some places, as the characters of the rocks and their fossil contents show, while in other places the complete absence of sedimentary deposits proves that the sea had retreated from many areas which it had previously covered.

As Hayden and Burrard have pointed out (**28**, p. 251), there is no evidence of any break in the continuity of marine deposits in the Himalaya from the beginning of the Muth (Ordovician and Silurian) period to the middle of the Carboniferous. "During the Devonian period the sea covered all the northern portion of the Himalayan area and extended eastwards into Burma, south-eastern Tibet and China. Westwards it appears to have extended through Kashmir, over what is now the Hindu Kush, into Afghanistan and northwards to the Pamir and the Tian Shan; its record is not very clear in the greater part of the Tibetan zone of the Himalaya, where fossils of Devonian age are scarce, having been found only at rare intervals." With the changes in the position and outline of the southern coast of the Tethys the Dravidian era of Indian geological

history comes to an end, and a series of important alterations in the distribution of sea and land began to take place in many parts of the world.

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LAKES OF THE SALT RANGE IN THE PUNJAB. BY T. D. LATOUCHE, B.A., F.G.S., *Officiating Director, Geological Survey of India* (with Plates 1 to 14).

Preliminary remarks.

CONSIDERING the interest that attaches to the occurrence and mode of origin of lakes in general, and more particularly to the small number that are known to exist in the arid districts of the Indian peninsula, it may seem surprising that so little attention has hitherto been paid to those that are situated in the Salt Range of the Punjab; for it must be confessed that, although they are by no means inaccessible, and have frequently been visited by geologists and others, the only information that we possess concerning them is somewhat meagre, and is confined to general remarks regarding their position, their size, and the salinity of their waters. And yet it may be said that these lakes have on examination proved to possess more interest, from a geological point of view, than most of the lakes that occur in desert surroundings are likely to afford, for such lakes are usually situated among accumulations of sand or silt of such thickness and extent as to conceal the solid rocks underlying the depression and effectually mask the relations between the rock-structure and the mode of origin of the basin, whereas in the Salt Range the accumulation of silt and blown sand in the immediate neighbourhood of the lakes is seldom so great as to conceal the structural features of the rocks among which they lie.

Of all the causes to which the origin of lake basins has been attributed, that due to the development of differential movements in the crust of the earth is the most difficult to demonstrate by direct evidence, because the comparatively slight deformation of the surface which is necessary for the formation of a rock barrier cannot as a rule be detected among rocks lying at high angles, as is usually the case where the lakes are situated in hilly districts. Any instance, therefore, in which it can be shown that the formation of the barrier is directly due to deformation of the surface, is worth recording.

Position of the lakes.

There are four permanent lakes, or "Kahars" as they are termed in the vernacular, in the Salt Range, besides several depressions which become flooded with water whenever the rainfall is more abundant than usual in that arid country. The average annual rainfall of the plateau of the Salt Range is about 15 inches, most of which falls in the summer months, when the temperature and the amount of evaporation are excessive. The permanent lakes are the Son-Sakesar, also known as the Samundar, or "Lake" *par excellence*,[1] situated on the large plateau known as the Son, at the foot of Sakesar hill, the culminating point of the range; the Kabaki Kahar, lying in a depression to the north of the same plateau; the Jalar Kahar, a small lake situated among rugged hills to the south-east of the Son-Sakesar; and, lastly, the Kalar Kahar, or "Salt Lake," which lies at the foot of the northern slope of the range, on the edge of the elevated tract of ground that stretches away to the north towards Rawalpindi, known as the "Potwar."

Previous notices.

The first geologists to visit these lakes were Dr. Andrew Fleming and Mr. W. Theobald, whose account of the geology of the Salt Range was published in the *Journal of the Asiatic Society of Bengal*, Vols. XXII (1853), pp. 229-279, 333-368, 444-452; XXIII (1854), pp. 651-677.[2] A short account of them is also given in Mr. Wynne's Memoir on the Geology of the Salt Range (*Mem., Geol. Surv. Ind.*, Vol. XIV, pp. 46, 62), and may be quoted here :—

"The hollows of the Son-Sakesar and Kabaki lakes on the western plateau of the range are open shallow depressions without visible outfall. The basin of the latter is small, but that of the former includes an area of about 60 square miles and occupies a singular position close to the highest elevations.

"The four salt lakes of the range form quite exceptional features to the general drainage. Three of them are on the western or Son plateau; two of these, the Kabaki and Son-Sakesar, or Samundar, lakes, in depressions of its northern part; and the other, the Jalar or Jalur lake, in the rugged country to the south. These three lakes vary in size with the amount of rainfall; they have no outlets, and are all salt or saline, though far removed from

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1 Hind. *Samundar* = the ocean.

2 References to the lakes will be found at p. 236 of Vol. XXII and p. 653 of Vol. XXIII.

and at a higher elevation than the salt-bearing strata. The largest of them is the Samundar lake, about 3 miles long and 1 wide. The fourth, the lake of Kalar Kahar, having a diameter of about a mile and only a depth of 3 or 4 feet, is situated close under the north side of the range. It has no outlet either except when flooded; a neighbouring nala[1] then affords a passage for the surplus water, and sometimes its white saline bed is all but dry.

"There may be various reasons for the saltness of these lakes, which differs in intensity, and would seem not to be derived from chloride of sodium only; ordinary precipitation from water, unable to escape except by evaporation, may have caused it. In the case of Kalar Kahar, brine springs at one place have an influence; and with regard to the Son, the saltness may be due to the former existence of overlying sandstones and clays charged with saline ingredients (p. 46).

"The salt lake basins of the Son valley present some peculiarity as to their excavation; the largest, the Samundar lake, at an altitude of 2,526 feet and with a catchment area of about 60 square miles, covers 6 (*sic*) square miles of surface, and varies in depth and area with the accession of rain-water, but is usually shallow. It has no visible outlet, and the difference between the altitude of the lake and that of the lowest part of the edge of its basin may be less than 100 feet. The greater part of the basin is formed of limestone and is rocky, but in an easterly direction there are large deposits of coarse detrital materials that may conceal some spot where the water could have escaped, before the passage was blocked up by their accumulation. No sufficient reason for calling in the aid of ice to assist in explaining the excavation exists, and though there may have been formerly subterranean passages through which dissolved portions of the limestone could be carried off, the saltness of the water indicates evaporation as the main cause to limit the area of the lake.

"The Kabaki lake at 2,481 feet of elevation is in an even deeper, though much smaller, depression of the Son; like the Samundar, it has no outlet either. It is 276 feet lower than the nearer summit elevations, and from 114 to 196 feet lower than the least elevated part of the margin of its basin; this also appears to be more completely a rock basin than the other, and both, if

[1] Hind. *Nala* or *Nullah* = a watercourse.

filled, would discharge into one of the heads of the Narsingphoar ravine. Another and smaller lake is that of Jalar to the southward, also without an outlet. All are situated in limestone tracts, and though probably connected with "swallow holes" or the damming up of former water passages, the size and form of some of the basins render local subsidence not at all an improbable cause for their existence.

"Under existing circumstances, and with nothing to carry away accumulating water except evaporation, these lakes must be gradually silting up."

The possibility of local subsidence, as one of the causes that may have contributed to the formation of the lake basins, is hinted at here, but Mr. Wynne gives no evidence in support of this supposition.

The Son plateau.

The principal or Son plateau of the Salt Range, on which the most important lakes are situated, extends from Pail on the east, where the range is traversed by a well defined fault, to the base of Sakesar hill on the west, a distance of about 26 miles. In breadth it varies from 2 miles near Jaba to 5 miles near Naushahra, the largest village on the plateau. On the north side it is bounded by the peculiar tract of broken ground which extends along the whole of the northern slopes of the range, and is known by the native name of "Khuddera." To the south it is bounded in part by the southern scarp of the range and the deep cañon of Narsingphoar, and further west by a fringe of very hilly country intervening between it and the plains, occupied by outlying patches of the Nummulitic limestone and by greatly disturbed and dislocated pre-Tertiary rocks. As Mr. Wynne says (*loc. cit.*, p. 201): "The table land possesses this peculiarity, that while the northern half presents the greatest sameness and simplicity of geological structure (if the formation of the lake basins be excepted), the southern side, particularly beneath the escarpment, is one of the most complicated tracts in the whole range, owing to the heterogeneous disposition of the groups by reason of dislocation, landslips, contortions, and erosion."

Geology.

For the most part the Son plateau is a broad expanse of Nummulitic limestone, whose bare white stony surface, reflecting the intense glare of a tropical sun, and devoid of vegetation except in those

places where wind-blown "loess" has collected in hollows, emphasises the arid character of the scenery. In this part of the range the limestone attains an average thickness of about 500 feet, forming the vertical cliffs which are so conspicuous a feature along the crest of the southern scarp as seen from the plains. Between Pail and Naushahra the limestone is encroached upon by the thick accumulations of sandstones and clays of later Tertiary age continuous with those which extend along the northern slopes of the range, deeply eroded by a labyrinth of narrow ravines, and reproducing, wherever the conditions are favourable, the features of the "Khuddera." Numerous detached outliers of the sandstones are also scattered over the surface, beyond the main northern escarpment, and testify to the former extension of these beds over the whole plateau.

The Kabaki syncline.

Between Pail and Jaba the limestones and overlying sandstones are practically horizontal, but to the north of the Narsingphoar ravine the surface quickly rises in a long, swelling wave-like curve extending from east to west (*see* Pl. 1). Eastwards this wave flattens out, and becomes merged in the horizontal plateau towards Jaba and Pail; but at a point about 4 miles south-west from Jaba the limestones roll over to the north, and are again bent up, forming a long narrow synclinal basin, stretching along the northern edge of the plateau to the foot of Sakesar hill, a distance of 18 miles in a direct line. The eastern extremity of this depression is seen to the right of the view shown in Pl. 2, which also shows one of the temporary lakes, the Khotaka Kahar, formed by water that collects in a hollow on the floor of the valley after heavy rains. The permanent lake of Kabaki lies a little further to the left, and the whole valley will be referred to hereafter in this paper as the "Kabaki syncline."

Denudation of the Tertiary sandstone.

Since the Kabaki syncline must have been at one time buried under an accumulation of Tertiary sandstones, in common with the remainder of the plateau, and the whole of these have been removed by denudation, it is necessary to consider in what way the sandstones can have been swept out, since there is now no apparent outlet from the valley. There are three ways in which this may have been effected; (1) the sandstones may have been washed down through fissures in the limestone below; (2) they may have been gradually reduced to dust by

sub-aërial agencies and blown out by the winds; and (3) there may have existed some outlet, open until quite recent times, but now concealed, through which their removal has been accomplished. Now, although the first two causes, especially the action of the wind, cannot be entirely excluded, it is difficult to see how they could account for the removal of such an enormous mass of rock, without leaving any remnants behind; and, as it happens, we are not compelled to accept either of them as sufficient to have effected the whole of the removal, since traces of the former existence of an outlet from the valley are still discernible.

Former outlet.

Not far from the western end of the syncline, and exactly opposite to the north-eastern shore of the Son-Sakesar lake, there is a broad gap in the limestone which forms the southern wall of the valley, and this gap is filled with an accumulation of silt, similar to that which is found at a considerable height above the present level of the water in the Son-Sakesar lake, an account of which will be deferred until I am dealing with that lake. The deposits in the gap are not horizontal, but are tilted up at various angles, in some cases fairly high, with a general dip to the north-west (*see* Pl. 3). It is therefore evident that since they were laid down, that is to say, in quite recent times, considerable earth movements have taken place along a line running north-eastwards through the gap. In fact there is no doubt whatever that a fault exists along the north-western shore of the Son-Sakesar lake, and that movement has taken place along this fault quite recently.

Since the silt deposits now found filling the gap are disturbed, it is evident that the gap itself was in existence before the fault reached its present stage of development, and in that case the drainage of the Kabaki syncline may have escaped through it, traversed the Son plateau, which was probably at a quite different level then, as compared with that of the floor of the Kabaki valley, than it is now, and flowed away either to the south or south-east, perhaps along the Narsingphoar ravine. The chief point to be noted is that the present configuration of the ground does not, owing to these recent earth movements, afford a guide to the conditions that existed when the sandstones that filled the Kakabi syncline were being removed.

Lake of the Kabaki Syncline.

Under favourable conditions of climate and rainfall, and supposing that the limestones on either side of the valley were water-tight, the Kabaki syncline would be filled with water to a maximum depth of over 100 feet, forming a single long, narrow lake. As it is, however, the rainfall is so deficient, and evaporation so excessive, that the water is confined to certain hollows lying below the general level of the floor of the valley. These are separated from each other by accumulations of silt, much of which is probably wind-blown "loess," and the hollows are merely due to irregularities in the deposition of this material. They are situated, as a matter of fact, in the lee of the higher portions of the ridge on the south side of the valley, the direction of the prevailing wind.

The Kabaki Kahar.

The chief of these hollows is that of the Kabaki Kahar, occupied by a sheet of water a mile long by three-quarters of a mile broad in ordinary seasons, but extending considerably beyond these limits after a good rainy season, as in January 1909, when the photograph (Pl. 4) was taken, and the area submerged was about 560 acres. The floor of the lake is quite level in the centre, with a maximum depth of 11 ft. 6 in. (January 6th, 1909) over a large area. On three sides, to the east, west, and south, the water shoals very gradually, but in the middle of the north bank a depth of 11 ft. was found at 50 yards from the shore, and the maximum depth only a little further out (Pl. 13, fig. 3). The greater depth on this side may be due to the steep inclination of the limestone which forms the shore here, or perhaps to a comparative defect in the quantity of dust blown into the hollow, in proceeding from south to north. The normal depth of the lake is indicated by the road which passes along the southern shore, and which at that time was 3 ft. under water. The small clump of trees seen standing in the water near the centre of the view marks the site of a well at the edge of the permanent lake, and shows the extent of ground that has been submerged by flooding.

The altitude of the lake above sea-level is 2,481 feet, the average elevation of the plateau to the south being about 2,600 feet.

The Khotaka Kahar.

The Khotaka Kahar is situated at about 2 miles to the east of Kabaki village, near the eastern end of the syncline (Pl. 5). At ordinary times it is a flat reedy meadow surrounded by fields, but in

January 1909 it was covered by a sheet of water nearly a mile long and half a mile broad, or about 320 acres, with a maximum depth of 4 feet, shoaling on all sides, but more gradually towards the ends than in a direction transverse to the valley. The road which runs along the north shore was 2 ft. under water (January 6th, 1909).

The Kocha Kahar.

The Kocha Kahar is a small temporary lake lying at the western end of the syncline, at the foot of the slopes leading up to Sakesar hill. The view (Pl. 6) shows how the sides of the syncline close in on either hand beyond the lake, and coalesce to form the northern flanks of the mountain. The lake is exactly similar to that of Khotaka, a nearly circular sheet of water, dried up at ordinary times, and very shallow.

According to the Gazetteer of the Shahpur District (Revised Edn. 1897, by J. Wilson, I.C.S., p. 9) the area of the Kabaki Kahar, at the settlement of 1863, was 260 acres; it fell to 146 acres in 1890; but in 1892, a year of exceptional rainfall, it rose to as much as 676 acres. The Khotaka Kahar covered an area of 404 acres in 1892, while that of the Kocha Kahar in the same year was about 100 acres.

The Son-Sakesar Lake.

Area of the lake.

The Samundar, or Son-Sakesar Kahar (Pl. 3), is the largest in the Salt Range, having a normal length of about 3 miles and a breadth of a little over a mile. In ordinary seasons it covers an area of about 2,000 acres, but in the dry season of 1890 the area fell to 1,128 acres. In 1892, after the heaviest rainfall within living memory, it extended over 2,550 acres, and submerged a large area of cultivated land round its margin. The drainage area of the basin is about 50 square miles, or 16 times the area of the lake. This almost exactly corresponds with the average ratio of the drainage areas of nine of the principal lakes of the English Lake District to their water surface,[1] and is very near that of eight of the

[1] H. R. Mill, Bathymetrical survey of the English lakes. Geogr. Journ., Vol. VI (1895), p. 162. Bassenthwaite Water is omitted from the calculation, as the ratio in the case of that lake is abnormally high, the drainage area being 44·2 times that of the lake.

lochs of Scotland.[1] Most of the water-courses that drain the hills surrounding the plateau disappear before reaching the lake, and are dry at ordinary times, but after rain has fallen the water they bring down oozes out from underground near the shores of the lake, rendering them more or less swampy. The lake lies at an altitude of 2,526 feet above sea-level, or 45 feet above the Kabaki Kahar, at the foot of the eastern slopes of Sakesar hill, which rises to an elevation of 2,484 feet above it, or 5,010 feet above the level of the sea.

Depth of the lake.

The depth of the lake varies with the seasons, and is subject to considerable fluctuations. I was informed that in very dry years it is possible to cross the basin on horseback in a direct line from Uchali to Chitta, a village on the western bank about a mile from the southern end, which implies that the level of the water would be at least 9 or 10 feet lower than it was on the 12th January 1909, when I took soundings along this line.

Contour of the lake bottom.

The contours of the lake bottom, as determined by soundings, appear to confirm the supposition that the existence of the basin is due to a fault parallel to and at no great distance from the north-western shore. On the other sides the water is quite shallow, and the banks very low; but on this side low hills of Nummulitic limestone rise directly from the shore, and on this side the water deepens comparatively rapidly, until the maximum depth is reached along a line parallel with the shore and about 400 yards from it. This area of greatest depth forms a broad trough, the bottom of which is practically level, extending north-eastwards for about a mile and a half from opposite Chitta village to a small rocky island close to the shore nearly due south of Ugali village. Soundings ranging up to 45 ft. 6 in. were obtained along this trough (*see* section, Pl. 13, figs. 1 and 2). Except on the north-west side the floor of the lake slopes up very gradually on all sides from this depression, and is in fact a continuation of the very gentle slope of the general surface of the Son plateau towards the base of Sakesar hill. The more abrupt descent on the north-west side and the limestone hills rising from the water's edge represent a fault scarp, trending from W. S. W.

Son-Sakesar fault.

[1] Sir J. Murray and F. P. Pullar, Bathymetrical survey of the fresh-water lochs of Scotland, Scottish Geogr. Mag., Vol. XVI (1900), p. 213.

to E. N. E., and striking directly towards the gap in the southern wall of the Kabaki syncline described above. Along this line the limestones are considerably disturbed, dipping towards the lake at an angle of 45° between Chitta and Ugali, and being much contorted on the hill to the west of the gap, seen on the right hand side of Pl. 3. Between Ugali and this hill there is another gap in the southern wall of the Kabaki syncline, partly filled with silt, through which there may have formerly been an escape for the drainage from the north-east flank of Sakesar hill into the lake basin.

Former extension of lake.

A former extension of the lake in a north-westerly direction is indicated by the existence of beds of fine silt, already alluded to, rising on the lower slopes of Sakesar hill to a height of 250 feet above the present water level. Similar beds of silt also occur on the shore of the lake near the village of Ugali, some of them containing crystals of selenite in large quantities, and are tilted to the N. N. W. at an angle of about 10° (Pl. 7). The beds of silt on the slopes above Chitta also dip in the same direction at angles up to 20°, and among them there is a very conspicuous band of fine white marl full of the shells of a small *Planorbis* and other fresh-water gasteropods in a very poor state of preservation, but quite recent in appearance. The tilting of all these beds seems to show that the latest movement along the lake fault was in an upward direction on the north-west side of the fault, and that the present configuration of the lake basin is due to this movement (*see* section, Pl. 12, fig. 1).

The Kalar Kahar.

Area and depth of lake.

The Kalar Kahar is situated at the foot of the northern slope of the Salt Range, in the Jhelum District, on the main road from Pind Dadan-Khan to Tallagang, and at the edge of the "Potwar," or tract of elevated ground extending northwards from the range towards Rawalpindi. It is nearly circular in shape, about a mile in diameter, and is very shallow, the depth nowhere exceeding 3 ft. 6 in. (January 27th, 1909). There is no outlet at ordinary times, but when the l ke is flooded there is an overflow into the Dhrab river, which runs within a short distance of the shore on the

north-east side. The bottom of the lake is remarkably flat over the greater part of the area, but the maximum depth occurs much nearer the southern shore than to the north and east, in which directions the water shoals very gradually. The height above sea-level is 2,171 feet, and that of the plateau to the south about 2,500 feet.

Origin of lake basin.

The most striking feature in the geology of the lake basin is the fact that this is the only locality along the northern slopes of the Salt Range at which there is a gap in the "Khuddera," or fringe of Tertiary sandstones forming the northern declivity of the range elsewhere, though they are present on either side of the basin, as is seen in the photograph (Pl. 8);[1] and that the steep scarp on the south side of the lake is composed of Nummulitic limestone. A wedge-shaped mass of the sandstones and underlying rocks has apparently been let down by a fault, or system of faults, of which one certainly runs from east to west along the southern shore of the lake, and another probably at right angles to this, between the western shore and the cliffs on that side (*see* section, Pl. 12, fig. 2).

Outcrop of salt marl.

The line of the E.-W. fault is marked by a number of springs, most of which are of fresh water, but one at least is salt. This spring issues at the south-west corner of the lake, just below the District bungalow (*see* Pl. 8, where the position of the spring is marked by the white patches at the foot of the slope in the foreground), from the base of a conical knoll (on the right of the view) composed of the red salt marl, the peculiar rock that underlies all the formations of the Salt Range, either squeezed up from below through the fault, or perhaps washed up by the water of the springs and re-deposited. The possibility that the marl has been brought into its present position by the latter means is indicated by the fact that the knoll is strewn with large blocks of travertine, which has certainly been deposited by the springs.

The basin of the Kalar Kahar appears, therefore, to have originated in the same manner as that of the Son-Sakesar, that is to say, by local movement along a fault; but the present features of

[1] This view was taken from practically the same position as the one given by Mr. Wynne in his Memoir. (*Mem. Geol. Surv. Ind.*, Vol. XIV, Pl. IV, p. 47.)

the lake are probably due to more superficial causes, namely, the drift of dust blown by the wind across the plateau, and settling as "loess" in the lee of the scarp. Since the rise of the hill to the south of the lake is fairly abrupt, and the prevailing winds come from that direction, there are probably eddies of wind which prevent the rapid accumulation of dust immediately below the scarp, causing the bulk of the deposition to take place further out on the plain and pond back the water.

The Jalar Kahar.

Position of lake.

The little lake of Jalar Kahar, the existence of which was apparently unknown to Europeans until it was visited by Dr. Fleming and Mr. Theobald in 1852 (*Journ. As. Soc. Beng.*, Vol. XXII, p. 237), differs from all those that have been described in this paper, both in the geological features of its surroundings and in its mode of origin. It lies in a deep valley parallel with the southern edge of the Son plateau, about 5 miles to the south-east of the Son-Sakesar lake, and is separated by about 6 miles of very rugged ground from the district rest-house at Katwahi, on the main road from Shahpur to Sakesar hill. The valley in which it lies is excavated along the axis of an anticline of Carboniferous limestones, the edges of which form scarps on either hand, trending due east and west (Pl. 9). Towards the west the sides of the anticline approach each other, and solid rock extends across the floor of the valley at a higher level than the lake, and it does not seem possible that an outlet to the valley ever existed in that direction; but eastwards the valley is filled by thick accumulations of "loess," and the drainage may at one time have escaped in that direction into the small river that flows by Katwahi to the southern plains. Mr. Wynne states[1] that an east and west fault passes along the foot of the northern limestone cliffs, exposing some of the underlying speckled and reddish sandstones here and there. This fault is more clearly marked further west (*loc. cit.*, p. 224).

Area and depth of lake.

The lake has an oval shape, measuring about 1,000 yards in length by 500 in breadth, and is not subject to as great fluctuations in area with the rainfall as the other lakes of the range, on account

[1] *Mem. Geol. Surv. Ind.*, Vol. XIV, p. 223.

of the comparative steepness of its shores, which are practically rockbound except on the eastern side. The maximum depth was found to be 10 ft. 6 in. (January 17th, 1909), and the floor very level, rising rather abruptly on the north side, where the cliffs rise directly from the water's edge, and a depth of 10 feet was found at about 50 yards from the bank; and more gently towards either end. Its height above sea-level is about 2,300 feet, that of the crest of the scarp on the north side being a little over 3,000 feet.

Loess in Jalar Valley.

As I have already mentioned, the valley to the east of the lake is partly filled with an accumulation of "loess" (Pls. 10, 11). On the southern side the upper surface of this deposit runs up to the crest of the scarp, and the sections exposed by erosion show that it is distinctly stratified, with a gentle inclination to the north (Pl. 11). This apparent tilt of the beds is perhaps not due to movements in the rock floor of the valley, but to the conditions under which the beds were deposited, by the prevailing winds from the south. The thickness of these beds gradually diminishes in an easterly direction, and the existence of the lake in its present form may be due to the unequal distribution of the "loess," as in the case of the lakes of the Kabaki syncline.

Present outlet from valley.

The southern wall of the Jalar valley is broken through, at a point about two miles east of the lake, by a narrow gorge, through which the drainage from the north side of the valley, after traversing the "loess" deposits, escapes southwards into the Kabaki stream. The "loess" has been deeply eroded by the head-waters of this stream and fashioned into a labyrinth of cliffs and pinnacles, or "Khuddera," the peculiar aspect of which is shown in the views. The original drainage of the valley does not, however, seem to have escaped by this gorge, the opening of which must be of later date than the accumulation of the "loess," and is due to the cutting back of the head-waters of the stream in modern times, an action which is still proceeding.

General Remarks.

Salinity of the lakes.

The total amount of salts contained in the water of these lakes varies, of course, with the seasons, the solution becoming more concentrated as the water evaporates in the dry weather. Samples taken from

each of the larger lakes in January 1909 gave the following results in the Geological Survey Laboratory :—

Lake.	Percentage of total salts.
Son-Sakesar	1·23
Kabaki	·86
Khotaka	·03
Kalar Kahar	·33
Jalar	·20

The only previous determination of the salts in any of the lakes that I am aware of is one mentioned by Dr. Fleming (*Journ. As. Soc. Beng.*, Vol. XXII, p. 250), who says that 500 grains of the water of the Samundar with a specific gravity of 1·02 yielded 14·97 grains of saline matter, or 2·99 per cent. The condition of the lake at the time the sample was taken is not stated, but it was evidently at a season when the brine was much more concentrated than in January 1909. The very low degree of salinity of the water of the Khotaka Kahar is, of course, due to the fact that this consists entirely of rain-water that has fallen only a few months previously.

The samples obtained were not sufficiently large to enable a complete quantitative analysis of the salts to be made, but a partial analysis by Mr. Blyth shows that in all cases there is a greater proportion of chlorides present than of sulphates. According to Dr. Fleming, the salts of the Samundar consist of sulphate of soda and chlorides of sodium and magnesium, with a trace of chloride of lime.

Method of taking soundings.

There do not appear to be fish of any kind in any of the lakes, probably because of the violent fluctuations in the degree of salinity of their waters, but they are visited by large numbers of wild fowl during the cold weather. Since there are no fish, the natives of the district have no need of boats, and there are none on any of the lakes except the Kalar Kahar, where the district officials keep one for sporting purposes. In making soundings I used an Acme canvas folding boat of American make, which is very convenient and portable, but can only be used for such work in the calmest weather, for it is so light that the slightest breath of wind causes it to drift. Fortunately the mornings in the Salt Range, during the

latter part of the cold weather, are almost invariably calm, though a breeze usually springs up towards noon. The plan adopted in making the soundings was to row for a certain number of strokes in a given direction, the average distance rowed being determined beforehand by measurement along the shore of the lake, and then, after stopping the boat, to take the soundings as quickly as possible, a slight correction in position being made afterwards for drift, if necessary. As I was alone it was not possible to correct my position by observations of fixed points on the shores, but the depths proved to be so uniform over considerable areas that extreme accuracy in this respect did not seem to be required.

Summary.

The present configuration of the lakes of the Salt Range is in all cases due to the irregular accumulation of deposits of wind-blown "loess," but the hollows in which these deposits have accumulated have been caused by earth movements, except perhaps in the case of the Jalar lake. The depression in which the Kabaki lakes lie takes the form of a long narrow syncline in Nummulitic limestone, while those of the Son-Sakesar and Kalar Kahar have been caused by faults along one side of the basins in which they lie. Tilted beds of recent silt in the neighbourhood of the Son-Sakesar show that these faults have reached their present development in quite recent times. The Jalar lake lies in a valley excavated along the axis of an anticline, the original outlet of which has been dammed up by deposits of "loess," but in this case also the depression of the floor of the valley in which the lake lies may have been partly caused by faulting.

All the lakes are very shallow and flat-bottomed, but some connection between the shape of their floors and the earth movements that have caused the depressions can be traced. There are no signs in any of them of "swallow-holes," or indications that the hollows are in any way due to underground erosion or solution of the limestone. They are subject to considerable fluctuations in depth and area corresponding with the rainfall of the region, but, excepting the Kalar Kahar, none of them are ever filled sufficiently to overflow, and the loss of water they sustain is entirely due to evaporation.

LIST OF PLATES.

A PRELIMINARY SURVEY OF CERTAIN GLACIERS IN THE HIMALAYA. BY OFFICERS OF THE GEOLOGICAL SURVEY OF INDIA (*continued from RECORDS, VOLUME XXXV, PART 4*).

D.—NOTES ON CERTAIN GLACIERS IN SIKKIM. BY T. H. D. LATOUCHE, B.A., F.G.S., *Officiating Director, Geological Survey of India* (with Plates 15 to 27).

THE work of demarcating certain of the glaciers of the Himalaya for the purpose of determining their secular oscillations, undertaken by the Geological Survey of India in 1906 at the instance of Mr. D. W. Freshfield on behalf of the *Commission Internationale des Glaciers*, has been completed for the present by the observation of two of the glaciers descending from the Kinchinjunga group in Sikkim; so that we now have a series of observations and plane-table plans of 14 glaciers, extending from the far North-West in Kashmir,[1] through Lahaul[2] and Kumaon,[3] to the furthest point eastwards that can be reached under present political conditions.

I.—THE ALUKTHANG GLACIER.

Route.

The Alukthang glacier (lat. 27° 35′: long. 88° 14′) is situated at the head of the Praig Chu, a tributary of the Rathong, one of the principal affluents of the Great Rangit, which joins the Teesta below Darjiling. The glacier is distinctly visible in clear weather from Darjiling, whence it may be reached in about a week by the road leading through Chakung and Rinchinpung to Pemionchi. As far as the last named place there is a good bridle road, but beyond this the journey should be performed on foot, though ponies might be taken one day's march further. Between Yoksum and Jongri the path is rough and precipitous, but not dangerous, and beyond Jongri it is open and easy, though not very well defined. Coolies

1 *Records. Geol. Sur. Ind.*, Vol. XXXV, Pt. 3, p. 127.
2 *Ibid* *ibid*, Pt. 4, p. 139.
3 *Ibid* *ibid*, Pt. 4, p. 148.

should be engaged at Darjiling for the whole trip, Sherpai Bhotias being the most reliable, and provisions for them must be carried beyond Pemionchi, though a limited amount of supplies may sometimes be obtained at Yoksum.

Aspect.

As seen from Darjiling, the glacier appears to descend directly from the southern face of Kinchinjunga, and even when a closer view is obtained this appearance is still noticeable (*see* Pl. 15), but as a matter of fact the gathering ground of the glacier is separated from Kinchinjunga itself by the deep valley of the Talung Chu, and the principal branch of the Alukthang glacier issues from a valley leading up to the eastern spurs of Kabru. The complicated relations of these glaciers are clearly shown in the excellent map constructed by Prof. E. J. Garwood, and published in the *Geographical Journal* for July 1902,[1] a portion of which is reproduced here, by the kind permission of the author (*see* Pl. 27).

Nomenclature.

A good deal of confusion has arisen regarding the nomenclature of this group of glaciers, nearly every published account giving a different name to them. Mr. P. N. Bose, in his 'Journal of a trip to the Glaciers of the Kabru, Pandim, etc.' (*Records*, *Geol. Sur. Ind.*, Vol. XXIV, Pt. 1, p. 55), gives the name of Kochirangkang and East Kochirangkang to the two principal branches, but as the main branch comes from the direction of Kabru, that is, from the west, I was unable to identify his description with the topography on the spot. Mr. Freshfield calls the whole group the Kabru glaciers, and distinguishes one that comes down to the Guicha La from the eastern spur of Kabru as the Guicha Glacier (*Round Kanchenjunga*, p. 226), but on Professor Garwood's map the name of Kabru Glacier is given to a small branch descending from Kabru itself to the glacier at the head of the Rathong, separated from the Praig Chu by a high ridge, and the name Alukthang is used for the glacier under description. I therefore propose to employ the latter name in this paper.

Former extent of glacier.

From Mr. Bose's very detailed description of the topography, it would appear that, at the time of his visit, the glaciers falling from the

1 Vol. XX, p. 136. A copy of this map is also included in Mr. D. W. Freshfield's book 'Round Kanchenjunga' (London, Edward Arnold, 1903).

north-west side of Pandim, south of the Guicha La, joined the Alukthang glacier, which, he says, "is formed by the union of three large glaciers,—one coming from Pandim, one proceeding from between Kochirangkang and a peak east of it, ... and the third from between the last named peak and another (also unnamed) to the north-east of it...." (*loc. cit.*); and in the oldest account of the glacier extant, that by Major J. S. Sherwill (*Journ. As. Soc. Beng.*, Vol. XXXI, p. 471), who visited it in November 1861, the description runs as follows:—"Having ascended the immense mass of débris forming the moraine, probably to an elevation of 15,000 feet, we found ourselves, to our great surprise, standing on the top of a stupendous glacier. This huge mass of ice and débris descending from the Pundeem mountain extends nearly across the valley, where it is met by, and abuts upon another glacier, equally vast in its dimensions, and formed at the base of the snow-clad mountains on the other, or western side of the valley, the two together forming a complete barrier across the valley and choking it up to the height of a thousand feet or more." And as he makes no mention of having to descend from the moraine and cross a ravine, in order to reach the ice, as would be necessary now, it is possible that, 50 years ago, the Pandim glaciers did join those to the west, and that, at the time of Mr. Bose's visit in September 1889, the connection had not entirely disappeared. If this is the case, the glaciers of Pandim must have retreated quite half a mile since Major Sherwill visited the locality. At the present time, as Mr. Freshfield has pointed out, travellers can reach the ridge between the Praig Chu and the Talung valley without once setting foot on ice (*loc. cit.*, p. 225).

On comparing the view of Kinchinjunga from Alukthang given in Mr. Freshfield's work (p. 222) with Pl. 15, it would appear that very little or no change has taken place in the aspect of the snout of the glacier within the last ten years. Mr. Bose speaks of the Praig Chu as issuing from the glacier to the left of the moraine on the east side, so that at the time of his visit (September 17th, 1889) the ice probably extended down to this point: but when I saw it (June 1st, 1909) no water was issuing from the snout, but the whole of the discharge came from the side of the glacier some distance further up, beyond the moraine lake called A by Mr. Bose. If his observation is to be relied on, it would seem that there has been a considerable retreat since he visited it.

Demarcation. The snout of the glacier, as it appears at present (Pl. 16), is entirely concealed by an accumulation of moraine matter, and it is therefore difficult to determine the exact point to which the ice extends; the ice cave, which is found at the end of most glaciers, being absent here. The first ice cliff met with in proceeding up the glacier, at the base of which an ice cave would probably be found if the débris were cleared away from its face, was therefore chosen as representing the lowest limit of the ice, and a plane-table plan (Pl. 25) was prepared showing the position of this cliff relative to four fixed points, marked respectively A, B, C, D, on the plan.

Of these points A is an outcrop of schistose gneiss on the left bank of the Praig Chu directly in front of the snout of the glacier, and is marked with 6 holes cut in the rock in the form of a triangle painted red, and with a large arrow and the letters G. S. I. 1909 in red paint on the rock beside it. The photograph (Pl. 16) was taken from this point, and shows, in addition to the ice cliff, the position of the marks C and D. B, a large boulder of gneiss lying at the foot of the old moraine to the right of A, was chosen merely for the purpose of measuring a base-line, and as the ice cliff is not visible from it, no photograph was taken. It is marked by holes arranged in a square and painted as before. C and D are on either side of the valley, a line joining them passing somewhat below the toe of the moraine. C is a block of gneiss embedded in the slope of the hill to the (true) right of the glacier, and is marked with holes in the form of a cross surrounded by a circle painted red, Pl. 17 giving a view of the ice cliff as seen from this point: while D is marked by a cairn on the ridge of the old moraine above B, the letters $\frac{\text{D.}}{\text{G.S.I.}}$ 1909 being painted on a large slab of rock beside it. The ice cliff as seen from this point is shown in Pl. 18. Future views taken from this mark should show any change in the position of the cliff relative to the end of the well defined spur seen in the background.

The distances and bearings from these marks to the ice cliff and to each other are given below, and are also shown on the plan :—

	Distance yds.	Compass bearing.
A to B	198	N. 22° 40′ E.
A to C	427	N. 33° W.
B to C	359	W. 29° N.
C to D	285	E. 16° 40′ N.
C to ice cliff	575	N. 8° W.
D to ice cliff	610	N. 36° W.

Moraines.

The whole of the Alukthang glacier, so far as it is visible from the moraines below Pandim, on the way to the Guicha La, is buried under an accumulation of moraine matter, no ice being visible except where it has sheared away in the form of cliffs (Pl. 19). In this respect it differs from all the glaciers of the North-West Himalaya with which I am acquainted, from Kumaon to Kashmir, where I have invariably found a stretch of comparatively moraine-free ice above the terminal portion of the glacier, although the glacier still further up may be almost entirely covered with median or lateral moraines; the reason being that the débris is precipitated into crevasses before it has travelled very far. This difference in habit may, I think, be attributed to several causes: first, the excessively precipitous character of the hills surrounding the head of the glacier, so much so that the snow does not collect as a nevé and form a true ice stream; secondly, as a corollary of the first proposition, the snow, precipitated from the surrounding cliffs in the form of avalanches, is already charged with débris, and thus the glacier, from the very beginning, is choked *to its fullest capacity* with moraine stuff; and thirdly, that the enormous precipitation of moisture in the form of rain in Sikkim, as compared with the N.-W. Himalaya, melts the surface of the glacier much more rapidly. The Alukthang glacier is in fact more of the nature of an ice-bound land-slide than an ice stream.

The numerous old moraines surrounding the Alukthang glacier indicate how greatly this group of glaciers has shrunk in recent years. Pl. 19 shows most distinctly how the glacier, which must once have been at least on a level with the crest of the embankment-like moraine on its (true) right has shrunk below that level; and the great moraines coming down from Pandim (Pl. 15) afford evidence that the whole of the valley above Alukthang was once filled with ice. How far this ancient glacier extended down the valley is not apparent, since there is no vestige of any old terminal moraine further down, but the U shape of the valley is maintained as far as the grazing ground of Thangme, about a mile below the existing glacier, and it probably extended at least so far as this.

The stratified appearance of the ice in the cliffs is rendered very clear by reason of the immense amount of dirt that it contains (Pl. 20).

II.—THE GUICHA GLACIER.

The Guicha glacier also descends from the ridge joining Kabru with Pandim, but in a south-easterly direction, towards the Guicha La, a pass of 16,430 feet leading across to the Talung valley, and is separated from the Alukthang glacier by a broad grass-covered valley strewn with boulders and surrounded by old moraines (Pl. 21). The whole glacier forms a single ice-fall, and is so cut up by crevasses that no moraine matter is carried on its surface. The tongue of the glacier rests upon a huge embankment of moraine stuff, partly laid down by itself and partly by an old glacier descending from the north-west slopes of Pandim. There is thus no solid rock close enough to the end of the glacier to enable permanent marks to be inscribed, and it is therefore not suitable for the purposes of the present enquiry, but for the sake of comparison with future photographs a mark, consisting of a triangle with the letters G. S. I. 1909 inside it, was painted on a rock situated 87 feet south-west from the point from which the view (Pl. 21) was taken. This point is on the end of an old moraine about half a mile from the end of the glacier, the lens of the camera pointing N. 11° W. A photograph kindly supplied to me by Mr. T. J. Hoffmann, taken in June 1892 from a point somewhat lower down the valley, but looking in the same direction, shows that the appearance of the glacier has altered very little, if at all, since that time.

III.—THE ZEMU GLACIER.

Route.

The Zemu glacier (lat. 27° 45′ : long. 88° 25′) is the largest in Sikkim, and is the only easily accessible one that descends directly from Kinchinjunga. It lies on the north-east side of that mountain, at the head of the Zemu river, a tributary of the Lachen, which latter river, on its junction with the Lachung about 15 miles lower down, becomes the Teesta. The glacier is about 16 miles in length and in addition to the east side of the Kinchinjunga ridge, drains the northern slopes of Simvu and Siniolchum. The general features of the Zemu valley have been described by Sir J. Hooker (*Himalayan Journals*, 1854, Chaps. XIX, XX), who spent the month of June 1849 in the valley, and made repeated efforts to ascend to the glacier, but was unable to penetrate the dense thickets of rhododendron beyond his camping ground. It was not until 1891

that the glacier was visited by Europeans, when Mr. Claude White, Political Officer in Sikkim, and Mr. T. J. Hoffmann, the well-known photographer of Calcutta, succeeded in reaching it by way of the Yumtso La, a pass of 15,800 feet leading across the southern wall of the valley from the Teesta (*Proc. Roy. Geogr. Soc.*, N. S. Vol. XIV, p. 613).

The glacier was visited in 1899 by Mr. D. W. Freshfield's expedition, and is described in Chapter VI of his book *Round Kanchenjunga.* The road by which his party travelled from Darjiling through Gangtok has been greatly improved within the last 10 years, and the mouth of the Zemu valley may be reached in eight ordinary marches for laden coolies from Darjiling. The path up the Zemu valley is, however, little better than it was then, and I found the bridge over the Lhonak, where Sir J. Hooker camped, in a very rotten condition; while the new bridge over the Zemu, mentioned by Mr. Freshfield at p. 100, was quite broken down. In June, however, there are usually snow-bridges to be found below the glacier, and I crossed by one of them. The distance from Lachen, where there is a good travellers' bungalow, to the glacier is not more than 16 miles, and it could be reached easily in a couple of days, or even in one if the path were improved.

Aspect of the glacier.

The snout of the glacier appears to be in much the same position now as it was at the time of Mr. Freshfield's visit. The ice is deflected by an old moraine on the southern side of the valley, so that it impinges directly against the steep hill side on the north. In the narrow space between the toe of the moraine and the hill side there is a line of ice cliffs facing east, from the base of which the drainage of the glacier issues through several ice caves, the largest of which is placed near the southern end of the line of cliffs (Pl. 22). Another considerable stream comes down the southern side of the glacier in the space between its lateral moraine and the hill side, and joins the main stream below the glacier (*see* plan, Pl. 26).

Demarcation.

Marks were placed on rocks near the snout of the glacier at three points, marked A, B, and C on the plan (Pl. 26). Of these A is placed on the top of a large flat mass of granite on the right bank of the main stream about 150 yards above its confluence with the side stream mentioned above. Three holes were cut in the rock at the apices of a triangle and painted red, with the letters G. S.

I. 1909 at the side. B is on a large rock at the base of the old moraine, 177 yards from A, and marked with four holes at the corners of a square painted in the same manner: and C is on a small cliff of live rock on the left bank of the stream opposite B, marked by five holes in the form of a cross surrounded by a large circle painted red, which is clearly visible from the path leading up to the glacier on the opposite side of the valley, and lettered as before. Photographs of the ice cliffs and cave were taken from A (Pl. 22) and C (Pl. 23), but none from B, as the principal cave was not visible from this point.

The following are the bearings and distances of the marks from each other and from the principal ice cave:—

	Distance. yds.	Compass bearin
A to B	177	W. 10° 40′ N.
A to C	200	N. 47° 40′ W.
B to ice cave	407	W. 35° N.
C to ice cave	385	W. 19° N.

The slip (x, Pl. 22) at the end of the old moraine and the continuous line of screes above C on the opposite bank made it impracticable to select points nearer to the snout of the glacier, to which marks likely to remain permanent could be affixed.

Mr. T. J. Hoffmann has kindly supplied me with a photograph of the snout of the glacier (Pl. 24) from which it would appear that there has been a considerable retreat since the time of his visit, in July 1891. The view is taken from a point somewhat higher up than A on the plan, between that and B, so that the slip x (the lettering denotes corresponding points in each view) is more foreshortened than in Pl. 22. But it will be seen that whereas in Mr. Hoffmann's view the terminal line of ice cliffs comes well below the rocks showing through the screes at y, it has now moved back, as Pl. 22 shows, almost as far as the rocks marked z.

Moraines.

During the two days that I remained at the glacier (June 22nd and 23rd, 1909), the upper part of the valley was buried in clouds and fog, and being without guides, none of my coolies having visited the place before, I did not care to venture towards the head of the glacier. Mr. Freshfield and Mr. Hoffman have, however, given accounts of the upper part of it, and Mr. Hoffmann has shown me

the photographs taken by him in 1891. From these accounts and views it appears that the whole of the glacier, as far as the foot of the precipices below Kinchinjunga, is almost as completely covered by moraine matter as that of Alukthang,[1] and that very little clear ice is to be found on its surface, though the views show that the tributary glaciers, which come down from Simvu, Siniolchum, and the Green Lake Glacier which descends from the peaks to the north of Kinchinjunga itself, are much more free from débris. Both observers mention the trenches along either side of the glacier, between its lateral moraines and the hill-side, the origin of which does not seem to be clearly understood. Mr. R. D. Salisbury (*Journ. Geol.*, Vol. IV, p. 800) thinks that in Greenland lateral moraines of this type may be caused by the upturning of layers of ice at the edges of the glacier, bringing the débris to the surface, but I have not noticed anything of the kind in any of the Himalayan glaciers that I am acquainted with, and I do not understand how, unless the moraines are already in position, the upturning of the layers of ice could take place. The usual explanation is that the trenches are kept open by running water flowing from the hill-sides, but I think that some more potent cause than the insignificant streams that traverse them is required to account for the facts. Indeed very often there is no trace of any watercourse in these trenches.

This cause, I think, may be found in the avalanches of snow precipitated from the steep sides of the valleys, and the trenches may perhaps have originated in the following manner. During the period of shrinking to its present size, the glacier would melt more rapidly along the sides, on account of the radiation of heat from the hill sides, than in the centre: at the same time, avalanches falling from the mountain sides would remain unmelted at first for the greater part of the year, and would shoot the débris falling down their slopes well out on to the glacier, thus forming a ridge parallel with its edges. As the shrinkage of the glacier proceeded, the trench thus formed would be filled each year with snow, which it is true would melt more quickly than the glacier ice, but would persist long enough, at any rate until a considerable amelioration of the climate had taken place, to prevent talus material from fill-

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[1] See the view of 'Kanchenjunga from Green Lake Plain' at p. 108 of 'Round Kanchenjunga.'

ing up the interval between the glacier and the hill side. At the same time the moraine thus formed would tend to keep the glacier confined to the centre of the valley. Finally, when the climate became so mild that all the snow falling from the slopes was melted during the summer, we would have a broad open trench between the glacier and the side of the valley, as we see it at present.

Present elevation of glaciers.

Both the Alukthang and the Zemu glaciers descend to about the same altitude above sea-level, namely, 13,000 feet. Comparing this with the altitude of the glaciers of the North-West Himalaya, we find that there is a regular decrease in the average altitude to which they descend as we proceed towards the south-east. As Sir T. Holland points out (*Records, Geol. Sur. Ind.*, Vol. XXXV, pt. 3, p. 125), the glaciers of Hunza and the Karakoram range come down to levels of 7,000 or 8,000 feet, while in Lahaul and Kumaon they melt before descending below the level of about 11,000 feet. This gradual elevation of the glacier line may be due in part to the decrease in latitude, which is roughly 36° in the first named region, 32° in Lahaul, 30° in Kumaon, and 28° in Sikkim; but it is also partly caused, I think, by the increased precipitation of moisture as rain as we proceed in the same direction. There are no statistics of rainfall available for places in the immediate neighbourhood of the glaciers, but the amount is probably proportional to that which falls at stations along the edge of the Himalaya; though it will depend to some extent on the distance of the glaciated ranges from the plains, and the number of intervening ridges, which are both much greater in the North-West than in Sikkim. The normal rainfall at the stations in question is given below:—

Station.	Normal Annual Rainfall inches.
Murree (for Kashmir)	55·85
Simla (for Lahaul)	63·59
Naini Tal (for Kumaon)	91·90
Darjeeling (for Sikkim)	124·38

Former extension of glaciers.

There is no ancient terminal moraine in the valley of the Zemu below the present glacier, but it probably extended at one time a good deal further down than it does now. Professor Garwood thought that

he could detect traces of former moraines as far down as Lachen, below the mouth of the Zemu, at an elevation of about 8,000 feet (*'Round Kanchenjunga,'* p. 287), but the conspicuous ridge that crosses the valley 'about a mile below the Monastery' and at first sight certainly looks like a moraine, appeared to me to consist mainly of solid rock, and the boulder drift between this and the village to be merely fans of talus shot out from the ravines on the western side of the valley. The strongly V-shape of the lower part of the Zemu valley also, and of the Lachen valley above the confluence of the streams, does not support the idea that the glacier ever came down so far.

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PLATE 23.—The same, from C.

PLATE 24.—Ice-cave, Zemu glacier, in July 1891.

PLATE 25.—Plan of Alukthang glacier.

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PLATE 27.—Sketch-map of the glaciers of Kinchinjunga (*after E. J. Garwood*).

NOTICES OF NEW MAMMALIAN GENERA AND SPECIES FROM THE TERTIARIES OF INDIA. BY GUY E. PILGRIM, D.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.*

As a result of the very thorough exploration of the Tertiary ossiferous deposits of India in which the Geological Survey of India are now engaged, a large amount of fresh material has already been collected. This has made it necessary to establish several new genera and species of mammals. Full descriptions and figures of most of those up to the present determined are in the press, but as their publication will be somewhat delayed it has seemed advisable to publish the present brief preliminary notice in order to avoid the possible duplication of descriptions or names by other workers on vertebrate palæontology. A revised classification of these beds and a complete list of the Tertiary mammalian fauna of India with the locality and stratigraphical horizon of each species is also in the press and will shortly be ready for issue.

Sivapithecus indicus n. gen. n. sp.

A specimen of the last lower molar of an anthropoid ape from the Lower Siwaliks of Alipur is of precisely the same dimensions as the corresponding tooth of *Gorilla savagei* and has the same shape and arrangement of cusps. The cusps are however lower and the deep valley separating the protoconid and hypoconid in *Gorilla* is absent. There is no trace of the external cingulum of *Gorilla*. The surface is rather wrinkled, but not more so than is often found in *Gorilla* and much less so than in *Simia*.

Dryopithecus punjabicus n. sp.

Maxillae and mandibles of this species occur in the Lower Siwaliks of Chenji. It is very near to *D. rhenanus*, but differs by the mesoconid being more in a line with the protoconid and metaconid.

Semnopithecus asnoti n. sp.

This species, from the Middle Siwaliks of Asnot, is known by some lower teeth. It is recognised as a *Semnopithecus* and not a *Macacus* by the greater tendency of the posterior cusps to form a trenchant crest. It is of the same size as *S. entellus* and smaller than the Upper Siwalik *S. palaeindicus*. It differs from *S. entellus* and the other species of *Semnopithecus* by the presence of a broad anterior cingulum, which projects slightly on the external wall of the tooth.

Dissopsalis carnifex n. gen. n. sp.

This is a Creodont from the Lower Siwaliks of Chenji, of which the nearest affinities seem to lie with *Apterodon*. In the upper dentition Pm_1 has been lost; the inner cusp of Pm_4 is stronger and more isolated than in *Apterodon* and M_2 has developed a long posterior blade something like M_1 of *Hyaena* or *Oxyaena*. No specimen of the mandible has the molars behind M_1 preserved so that their presence is only presumptive. M_1 resembles the corresponding tooth of *Hyaena*, possessing two equal blades and a small simple talon without any trace of an inner cusp. Except for the absence of the cingular ridges it is not so unlike M_1 of *Pterodon*. The premolar series is as in *Hyaena*. Length of M_1 to Pm_2 is 73 mm.

Dissopsalis ruber n. sp.

This species occurs in the same beds as the preceding one, and is inferior to it in size, but differs in no very essential points of structure.

Amphicyon lydekkeri n. sp.

This species is founded on M_1 from the Middle Siwaliks of Padhri, which differs from M_1 of *A. palaeindicus* Lyd. from Kushalgarh by its greater size and squareness.

Palhyaena indica n. sp.

This species is established on a maxilla, found at Asnot, which is somewhat inferior in size to *Palhyaena hipparionum* Gerv., and has rather broader molars. It is almost certain that the mandible,

described by Lydekker under the name of *Hyaena sivalensis* Bose, also belongs to this species. In it the last premolar is more nearly equal in size to the carnassial than is the case in *P. aff. hipparionum* described by Schlosser from China. The fragmentary tooth, described and figured by Lydekker as the lower carnassial of *Hyaenodon*, is, as Schlosser has pointed out, an upper carnassial. It is probably a species of *Palhyaena*, to which I shall provisionally refer it.

Palhyaena proava n. sp.

This is a very much smaller species than the preceding, with relatively narrower teeth. It comes from the Lower Siwaliks of Chenji.

Pseudaelurus chenjiensis n. sp.

A maxilla from the Lower Siwaliks of Chenji is closely allied to *Pseudaelurus quadridentatus*. It indicates a species, which was inferior in size to the European form, and in which there is a complete absence of any diastema. The carnassial tooth is also proportionately larger, since it is of the same absolute length as the corresponding tooth in *P. quadridentatus*, although Pm_3 is smaller than in that species.

Cadurcotherium indicum n. sp.

In the list of the Upper Nari fauna of the Bugti Hills given by the present writer appears the name *Amynodon* sp. A more thorough development of the specimen reveals clearly that it belongs to the European Oligocene genus *Cadurcotherium*. The species differs from *C. cayluxi* (1) by its greater size, (2) the shortness of M_1 as compared with M_2 and M_3, (3) the metaloph more nearly in a straight line with the ectoloph.

Aceratherium bugtiense n. sp.

From the Upper Nari of the Bugti Hills; allied to *A. perimense*, but larger and more primitive in character, possessing no crochet and a hardly appreciable postfossette.

Aceratherium lydekkeri n. sp.

A skull from the Lower Siwaliks of Dhariala, though closely allied to the skull dug out at Niki by Theobald and described by

Lydekker under the name *A. perimense,* belongs to a distinct species. It is smaller and more dolichocephalic. The teeth show precisely the same variation from the Middle Siwalik species which Lydekker has remarked in those from Perim Island. It is therefore necessary to refer the Dhariala skull to Falconer's species *A. perimense* and to establish a fresh specific name for the Middle Siwalik skull and teeth described by Lydekker.

Diceratherium naricum n. nom.

This new name is proposed for the maxilla described by Lydekker as *Aceratherium blanfordi* var. *minus*. The premolars of *Aceratherium blanfordi* var. *majus* (probably a *Teleoceras*), which have now been found in the Upper Nari series of the Bugti Hills, are quite different in character from those of *Aceratherium blanfordi* var. *minus* and belong to a much more brachycephalic animal. They possess no cingulum.

Diceratherium shahbazi n. sp.

This species from the Naris of the Bugti Hills, is rather larger and has more elongated teeth than *D. naricum*. The premolars have a pectinate crotchet and are in a backward state of development. It is somewhat closely allied to *D. douvillei* Osborn.

Teleoceras fatehjangensis n. sp.

This species, also an Upper Nari form, is founded on a palate obtained near Fatehjang. It resembles *T. blanfordi* closely, but the ectoloph of the premolars, and to a less extent of the molars, has the remains both of the metaconal as well as of the paraconal fold.

Hipparion perimense n. nom.

This specific name is intended to receive the Perim Island skull described by Lydekker. Very perfect skulls of *H. punjabiense* Lyd. and *H. theobaldi* Lyd. obtained from the Middle Siwaliks of Dhok Pathan have shown that these two species are quite distinct. *H. punjabiense* has a much larger higher skull and the facial cavity is deeper and farther from the teeth.

Hippodactylus chisholmi n. sp.

A skull of this species was found in the Middle Siwaliks at Dhok Pathan. It is smaller than either of the other species of *Hipparion*. Pm_1 is present. The enamel folds of the fossettes are less complex. The protocone is larger and united with the protoconule in a very advanced state of wear. There is a large facial cavity, somewhat nearer the orbit than in the other Indian species. It was probably monodactyl. It differs from *H. antelopinus*, so far as this species is known, by the larger M_3 and the much squarer-crowned teeth.

Mœritherium (?) n. sp.

A small primitive Proboscidean molar found among the material from the Bugti Hills appears to differ but little from Andrews' genus from the Fayum in Egypt. It is therefore provisionally referred to *Mœritherium*.

Phyllotillon naricus n. gen.

This name is to replace *Macrotherium naricum*, a Chalicotheroid from the Nari series of the Bugti Hills. The new genus differs from the other members of the family by the greater elongation of its molars, but chiefly by the fact that in the upper premolars the large inner cusp is united to the ectoloph by a double instead of a single crest.

Schizotherium (?) sp.

A poorly preserved maxilla, also from the Naris of the Bugti Hills is provisionally placed here. It only slightly exceeds *Schizotherium modicum* in size and Pm_2 has exactly the same shape as in that species.

Tetraconodon minor n. sp.

Amongst Noetling's and Grimes' collections from Yenangyaung in Burma are some lower premolars, which in structure are exactly like those of *Tetraconodon magnus* Lyd. from the Middle Siwaliks of the Punjab. Since they are very inferior in size it seems convenient to make of them a fresh species. Maxillæ, probably belonging to the same species, are also contained in the collection.

Hippohyus lydekkeri n. sp.

I propose to apply this name to the smaller species of *Hippohyus* mentioned by Lydekker and confined to the Middle Siwaliks.

Brachyodus africanus, Andrews.

I am now of the opinion that *B. bugtiensis* is to be regarded as a synonym of the Egyptian species. The upper molars of the latter are unfortunately unknown, but the mandibles of the two forms appear to differ so little as not to warrant a specific separation.

Merycops longidentatus n. gen.

This species, referred to as *Brachyodus longidentatus*, has been made the type of a new genus by virtue of its longer, more hypsodont teeth and its Merycopotamine lower dention.

Hyoboops naricus n. sp.

This name is to supersede *Choeromeryx grandis* for the two small Nari teeth, as it seems to me that their affinities are rather Brachyodine than Choeromerycine.

Telmatodon (?) n. sp.

A small and fragmentary upper molar from Sind provisionally referred by Lydekker to *Agriochoerus* has a structure so similar to that of *Telmatodon bugtiensis* as to suggest that it belongs to the same or a closely allied genus. A lower molar found by Mr. Cunningham Craig in the upper beds of the Pegu series of Burma may belong to the same species.

Dorcabune anthracotheroides n. gen. n. sp.

This interesting species from the Lower Siwaliks of Chenji shows the most extraordinary mingling of Traguloid and Anthracotheroid characters. Its upper molars may be described as like those of a *Dorcatherium*, only of an extreme bunodont and brachydont type. Parastyle and mesostyle are prominent and isolated. The protoconal crescent is incomplete posteriorly with two marked folds

much as in *Telmatodon* and *Hemimeryx*. There is a prominent cingulum and a strong rugose sculpture. M_3 is 26 mm. broad and 22·5 mm. long. The same type of structure is displayed in the lower teeth, which, however, differ less, qualitatively, from *Dorcatherium* than the upper ones. The characteristic posterior fold in the protoconid is present. On the whole, the genus may be appropriately placed in the Tragulidae. Lower molars of the species occur in Sind.

Progiraffa sivalensis Lyd.

A detailed examination of the Giraffidae of India, the results of which are already in the press, has convinced me that the upper molar from Rurki described by Lydekker under the name of *Propalaeomeryx sivalensis* has Giraffoid affinities. Identically similar molars have been found in the Lower Siwaliks of Chenji in association with mandibles belonging to the genus *Progiraffa*.

Giraffa punjabiensis n. sp.

After careful consideration I am inclined to regard the Middle Siwalik species from the Punjab as distinct from the Upper Siwalik species from the Siwalik hills.

Giraffokeryx punjabiensis n. gen. n. sp.

This is a small genus of Giraffoid, from the Lower Siwaliks of the Salt Range, allied to *Helladotherium*, but with more primitive characters

Helladotherium grande Lyd.

It has been necessary to alter the generic designation of this species. A skull obtained from the Middle Siwaliks of Dhok Pathan renders its generic separation from the Pikermi genus impossible.

Indratherium majori n. gen. n. sp.

This new name is proposed for the reception of the Giraffoid hornless skull from the Markanda valley, now in the British Museum. Dr. Forsyth Major showed its distinctness from *Helladotherium*. It differs from *Hydaspitherium* by the greater proportionate breadth of the teeth, by the enormous size of the premolars, and by the

presence of frontal horn swellings, which lead one to suppose that if it be a hornless female, then the male would have frontal horns instead of the parietal ones of *Hydaspitherium megacephalum*.

Hydaspitherium magnum n. sp.

This Middle Siwalik species from Asnot is much larger than *H. megacephalum* and is distinguished from it by its relatively stouter and shallower mandible.

Hydaspitherium birmanicum n. sp.

A single upper molar, found near Singu in Upper Burma, differs little from *H. megacephalum* except by its much smaller size. The front horn of the 2nd crescent is not so long and the enamel folds penetrate the crown less deeply.

Boselaphus lydekkeri n. sp.

I propose this specific name for the Middle Siwalik teeth from the Punjab described and figured by Lydekker. I have carefully compared them both with *B. namadicus*, *B. tragocamelus* and teeth from the Upper Siwaliks of Kangra, and find that they are sharply distinguished from all of these by their greater brachydonty and by the weaker costae on the external lobes. *B. namadicus* is a larger species, and may be distinct from the Upper Siwalik form, but as the Kangra teeth show no important differences of structure from the Narbada ones, I cannot, in the absence of further material, differentiate the two.

Tragocerus punjabicus n. sp.

A fine skull, excavated from the Middle Siwaliks at Dhok Pathan, shows the distinctive characters of this genus. The great longitudinal diameter of its horn cores allies it to *T. amaltheus* Gaudry, from which, however, it is distinguished by the presence of a deep lachrymal fossa. It is smaller than *T. rugosifrons* Schloss., but the premolars are relatively longer. This is even more the case when we compare it with *T. spectabilis* Schlosser. In *T. gregarius* the premolar series is long as compared with the molar series, although the premolars are short relatively to their breadth, while Pm_4 is of a very complex structure. *T. sylvaticos* and *T. kokeni* are larger, less known species from China, of which the generic position is far from certain.

Tragocerus perimensis Lyd.

The horn cores and calvarium from Perim Island, described by Lydekker as *Capra perimensis*, must, I think, be referred to the genus *Tragocerus* to which they approximate closely in character. Tragocerine teeth occur in the probably contemporaneous beds of Chenji in the Salt Range.

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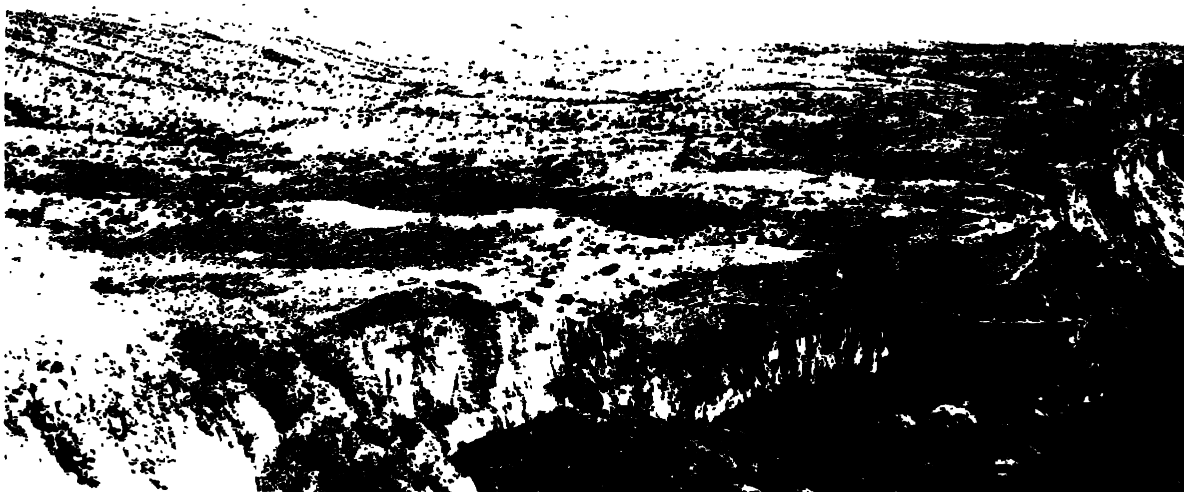

Photo by E. H. Pascoe.

G. S. I. Calcutta.

THE CHAMIL PLATEAU, SHOWING MONOCLINAL FLEXURE IN NUMMULITIC LIMESTONE

NARSINGPHOAR RAVINE IN FOREGROUND

Photo. by T. D. La Touche

G. S. I. Calcutta

THE KABAKI SYNCLINE (EASTERN END), WITH KHOTAKA KAHAR, LOOKING NORTH FROM CREST OF KALIAI RIDGE

Photo. by T. D. LaTouche. G. S. I. Calcutta.

THE SON SAKESAR KAHAR (SAMUNDAR), AND SAKESAR HILL, SHOWING TILTED BEDS OF SILT IN FOREGROUND.

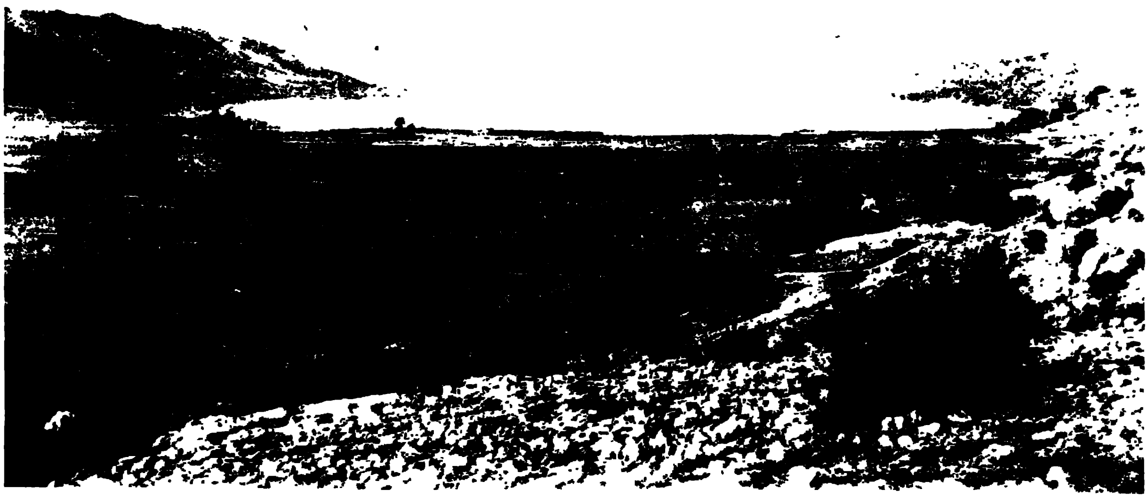

Photo. by T. D. LaTouche. *G. S. I. Calcutta.*

THE KABAKI KAHAR FROM THE EAST, SAKESAR HILL IN THE DISTANCE

Photo by E. D. [illegible]

[illegible]

EASTERN END OF KALAKI SYNCLINE WITH KHOTAKA KAHAR

Photo. by T. D. LaTouche

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WESTERN END OF KABAKI SYNCLINE AND SAKESAR HILL, WITH KOCHA KAHAR.

Photo. by T. D. LaTouche

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TILTED BEDS OF SILT, WITH INCRUSTATIONS OF SALT, NEAR HEAD OF SON SAKESAR KAHAR.

Photo. by T. D. LaTouche. G. S. I. Calcutta

THE KALAR KAHAR, FROM THE DISTRICT BUNGALOW. 'KHUDDERA' OF TERTIARY SANDSTONES IN THE DISTANCE. SALT SPRING AND RED MARL TO RIGHT.

Photo. by T. D. LaTouche

G. S. I. Calcutta

THE JALAR KAHAR, FROM THE SOUTH-WEST.

Scarps of Carboniferous Limestone in the background.

Photo. by T. D. LaTouche.

ERODED 'LOESS,' 'KHUDDERA,' IN THE JALAR VALLEY.

G. S. I. Calcutta.

Photo. by T. D. La Touche

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ERODED 'LOESS', 'KHUDDERA', IN THE JALAR VALLEY.

Showing inclined position of beds

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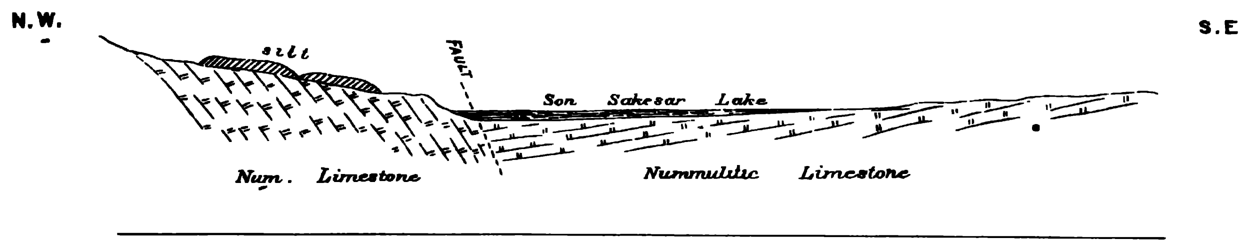


FIG. 1. SKETCH SECTION ACROSS THE SON SAKESAR LAKE-BASIN.

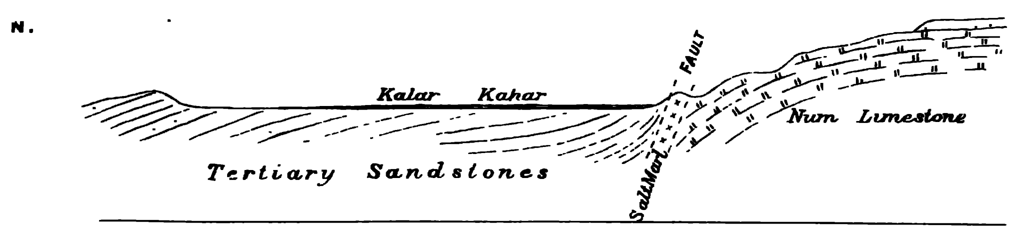


FIG. 2. SKETCH SECTION ACROSS THE KALAR KAHAR LAKE-BASIN

FIG. 1. LONGITUDINAL SECTION OF SON SAKESAR LAKE, ABOUT 500 YDS. FROM N.-W. SHORE.

FIG. 2. CROSS SECTION OF SON SAKESAR LAKE.

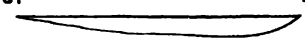
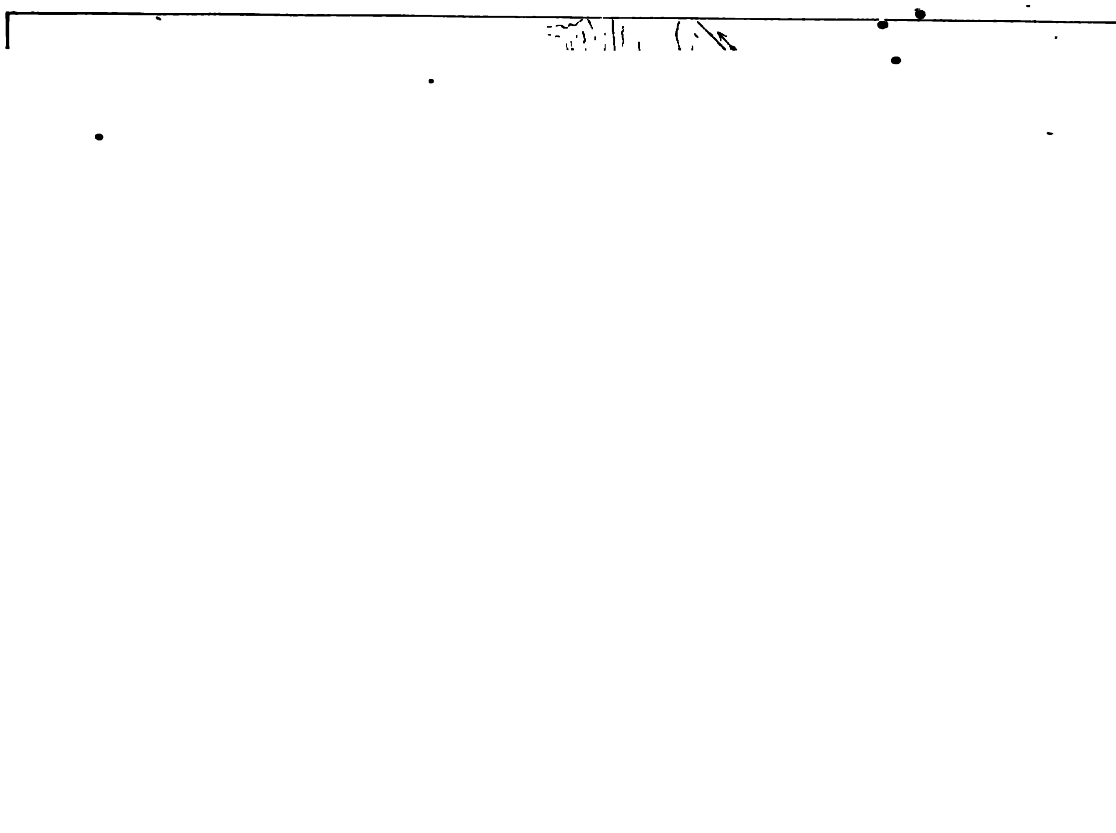


FIG. 3. CROSS SECTION OF KABAKI KAHAR.

Horizontal Scale 1" = 640 yds.

The upper line represents the depth approximately on a natural scale; the lower line the depth exaggerated twenty times.



KINCHINJUNGA, FROM ALUKTHANG.

Photo. by T. D. LaTouche. G. S. I. Calcutta

KINCHINJUNGA, FROM ALUKTHANG.

Photo. by T. D. LaTouche. G. S. I. Calcutta.

ALUKTHANG GLACIER, FROM A.

Photo. by T. D. LaTouche.

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ICE CLIFF ON ALUKTHANG GLACIER, FROM C.

Photo. by T. D. LaTouche

ICE CLIFF ON ALUKTHANG GLACIER, FROM D.

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ALUKTHANG GLACIER, FROM CHEMTHANG.

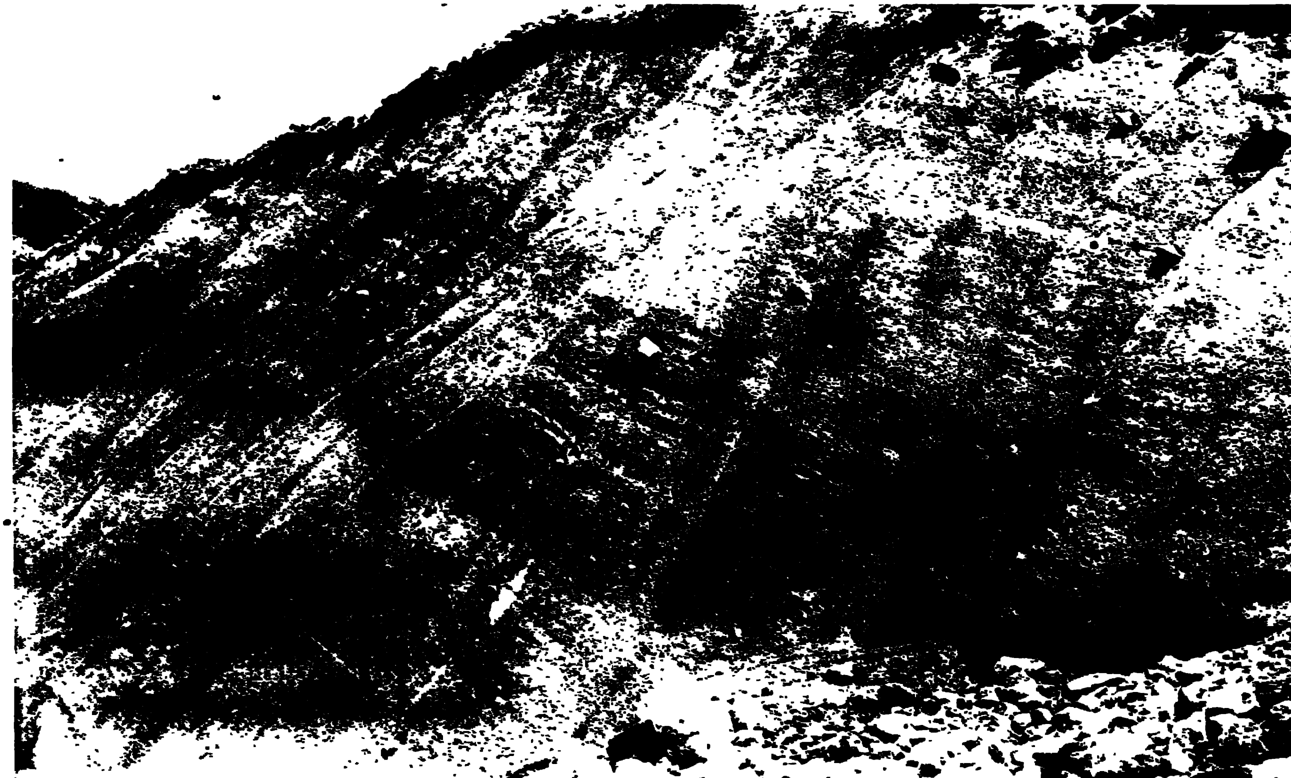

Photo. by T. D. LaTouche.

STRATIFICATION OF ICE, ALUKTHANG GLACIER.

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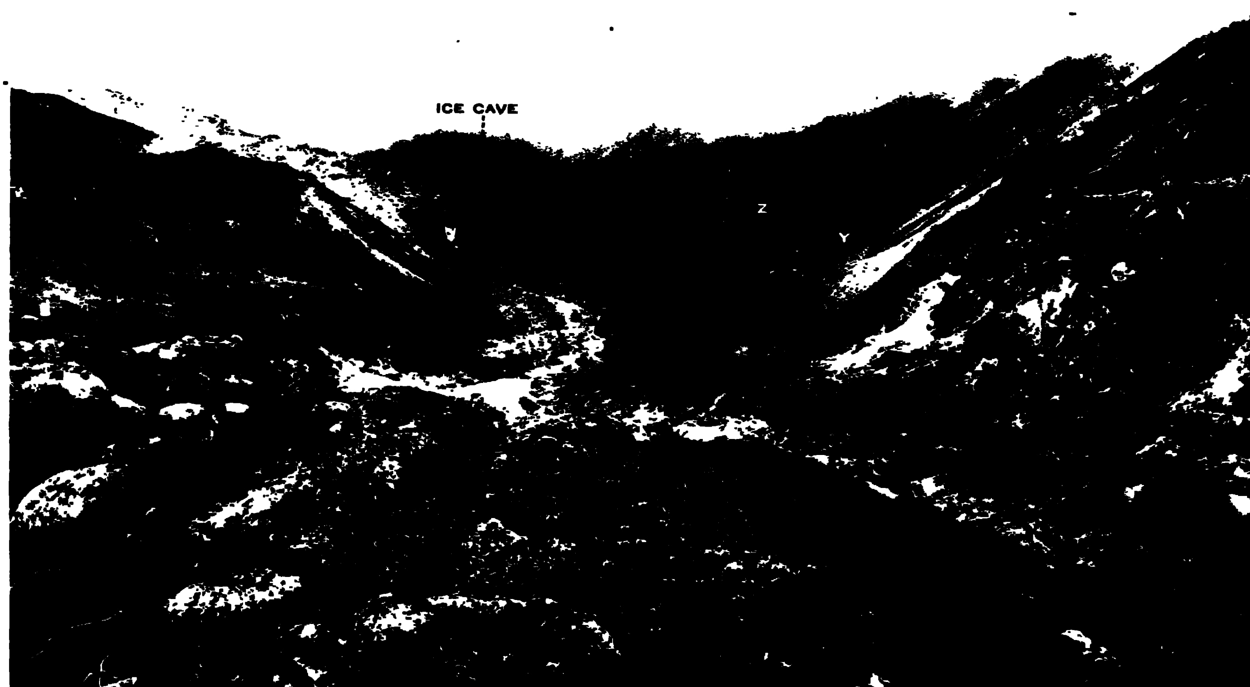
GUICHA GLACIER.



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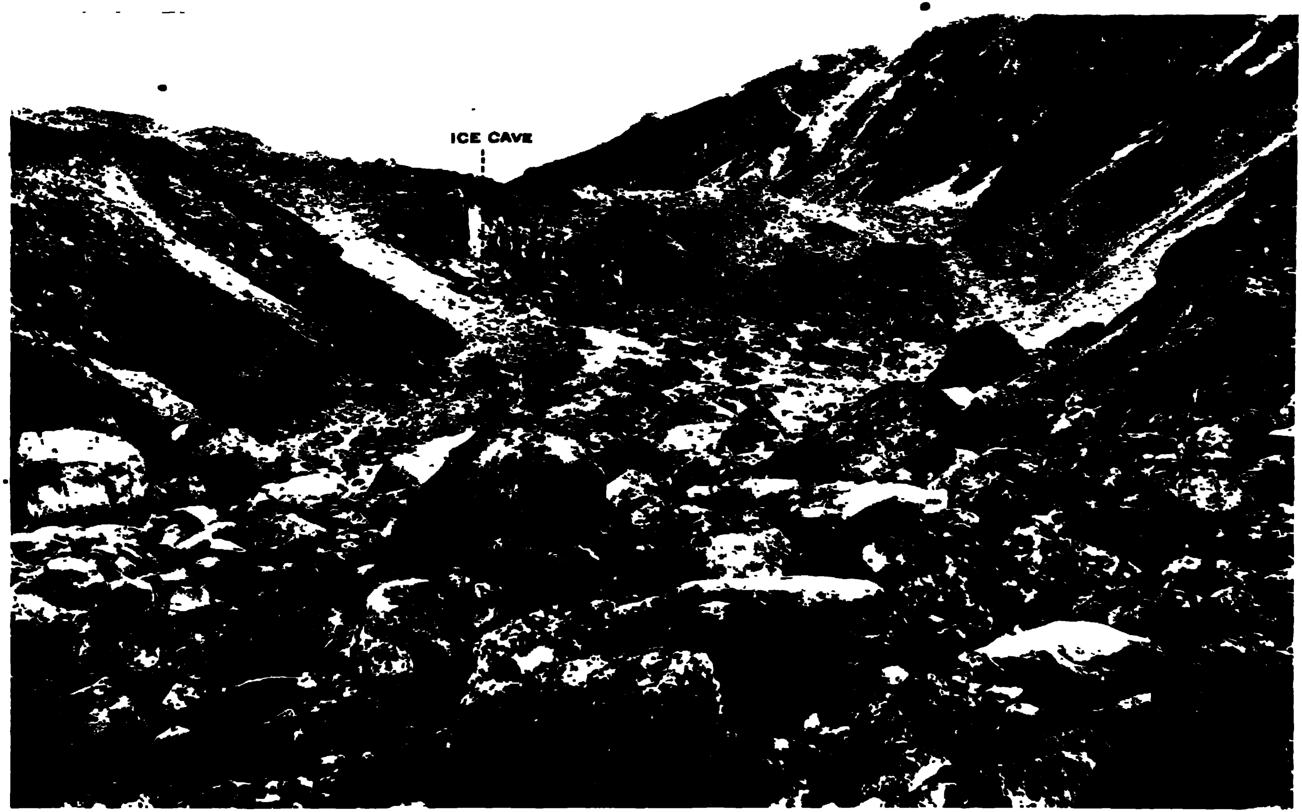
ICE CAVE, ZEMU GLACIER, FROM A.



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ICE CAVE, ZEMU GLACIER, FROM C.

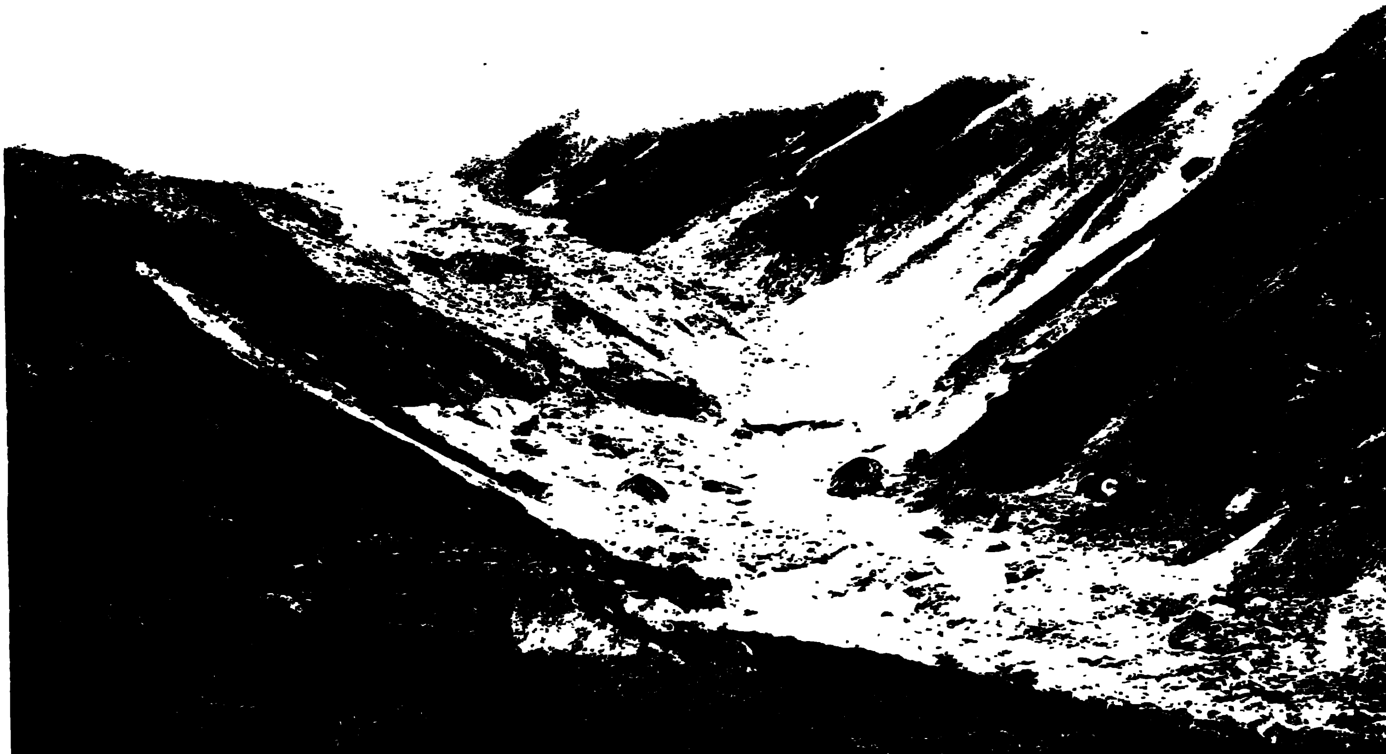

Photo. by T. J. Hoffmann.

ICE CAVE. ZEMU GLACIER. IN JULY 1891.

G. S. I. Calcutta.